Popular Astronomy.

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FEASIBILITY OF OBTAINING THE SOLAR PARALLAX FROM SIMULTANEOUS MICROMETER OBSERVATIONS OF EROS.

The unusual opportunity offered by the coming opposition of Eros for the determination of the solar parallax has been noticed in several journals, but the apparent facility with which simultaneous observations with filar micrometers at widely separated stations could be utilized has received little or no attention, the photographic method having been given the preference to the exclusion of the former. Although the parallactic factor, by suitable selection of stations may be made considerably larger, there are some inherent difficulties which do not occur in the method here proposed.

The high declination of the planet makes it possible to secure simultaneous observations at all the European observatories west of Pulkowa, and all the American observatories east of Denver, which are provided with sufficiently powerful telescopes. The following scheme in tabular form gives the Greenwich mean time at which the planet will be simultaneously visible, and at sufficient altitude to enable good observations to be made. At the most favorable time with reference to the parallactic factor, however, as well as at the beginning and end of the proposed series, daylight interferes with some of the observatories situated at the ends of the line, and it has been necessary to select two instants, one of which includes all except the extreme eastern, the other all except the extreme western.

The parallactic displacement varies from approximately 17″.0 to 30″.0 in the case of Pulkowa-Washington, to 14″.9 to 24″.5 in the case of Greenwich-Washington. The inclusion of Denver somewhat increases these quantities.

The principal difficulty in the proposed scheme is the selection with certainty of the same star or stars by the different observers.

NOTE.—This circular was prepared by S. J. Brown, Astronomical Director of the United States Naval Observatory, and it has been sent to the Astronomers of the United States who are willing to coöperate in the observations mentioned, and who are provided with suitable instruments for making them. Director Brown, also prepared a paper on the same subject which was presented before the International Astrophotographic Conference held in Paris, July, 1900. Ed.]

The planet will be situated in the Milky Way during the greater part of the time embraced in the series, which will afford many faint stars, but render their proper selection at the time of observation and future identification difficult. Experience shows that in the region of the Milky Way, the field of a telescope pointed at random will contain several stars from the 10th to 12th magnitude within a radius of 6′ of arc.

There would seem to be *a priori*, not much doubt that one or more stars as bright as the 11th magnitude would be found within a radius of 3′ of arc, from the true position of the planet as a center. The two or three brightest lying within this distance should be taken, limiting the choice if possible to magnitudes fainter than the 5th.

It will be necessary for the identification of the stars used that a careful sketch map of the field and the region immediately surrounding it, be made at the time of the observation, and that a photograph of the region be taken at about the same time. This would not only serve to identify the stars used, but, in cases where different observers should fail to select the same stars, it would furnish an accurate means of referring the observations to a common origin.

The coöperation of two or more photographic telescopes would obviate entirely the selection of the same reference stars by the different observers, as well as the necessity of adhering closely to the schedule time laid down for the observations, as the motion of the planet could be accurately computed for brief intervals of time thus arising, while the relative places of the stars used could be very accurately measured from the plates. At the same time the positions of the stars could be determined from the plate with sufficient accuracy to furnish the data for computing the coefficients in the equations of condition. The Naval Observatory has no suitable photographic telescope for this purpose, and with the exception of Harvard College Observatory there is none in this country. Except for this reason there would be no gain in resorting to micrometric observations. It will therefore be essensial to the complete success of the proposed scheme that one or more of the European observatories should take this portion of the work.

On account of the rapid motion of Eros, which makes observations of position angle and distance very troublesome, and also the ease and accuracy with which differences in its right ascension and declination can be interpolated, the measures should be

made in rectangular coördinates, referred to the true equatorial position of the fixed wire of the micrometer. Also it is important to eliminate as far as possible any lack of parallelism of the micrometer wires by taking the measures of each coördinate in two positions of the micrometer differing 180° in position angle.

EROS.

Scheme for Simultaneous Observations.

Date.	G. M. T. of Transit. At Greenwich. h m	Decl.	Hor. Par.	G. M. T. of Obs'n. h m
			″	
Oct. 1	14 02	45	15.4	14 30
				16 40
11	13 21	49	17.4	14 20
				16 00
21	13 33	52	19.4	14 00
				15 00
31	11 37	54	21.5	13 20
				14 20
Nov. 10	10 38	54	23.5	13 10
				14 10
20	9 40	53	25.2	12 15
				13 15
30	8 50	51	26.5	11 40
				12 50
Dec. 10	8 11	47	27.4	11 20
				13 00
20	7 43	43	27.5	11 20
				13 00
30	7 20	39	27.9	11 20
				13 00
1901				
Jan. 9	7 12	34	27.5	11 20
				12 20
19	6 53	30	26.9	11 10

INTERNATIONAL ASTROPHOTOGRAPHIC CONFERENCE OF JULY 1900.*

In conformity with the expressed objects of the conference, a special committee was appointed to prepare a general plan for systematic observations of Eros at the coming opposition, by which the widest co-operation of the observatories of the world would be secured.

The committee, besides the President, M. Loewy, comprised:
Messrs. André, Director of Lyons Observatory
Bakhuyzen, " " Leiden "
Christie, " " Greenwich "

* Translated for Popular Astronomy from the French by S. J. Brown of the United States Naval Observatory, who also prepared the concluding paragraphs embodying some helpful explanations. Ed]

Elkin, Dirctor of New Haven Observatoy.
Gill, " " Cape "
Hartwig, " " Bamberg "
Henry (Prosper), Astronomer of Paris Observatory
Trépied, Director of Algiers Observatory
Weiss, " " Vienna "

The committee adopted the following resolutions:

I. It is desirable that the determination of the parallax of the planet Eros should be made by means of micrometric, photographic and heliometric measures:

(*a*) by means of observations of the planet in the east and in the west at the same observatory;

(*b*) by the coöperation of observatories of Europe and North America.

(*c*) by the coöperation of observatories of the northern and southern hemispheres.

II. During the period of the observation for parallax, the motion of the planet Eros should be determined as accurately as possible, by means of micrometric, heliometric and photographic measures.

III. The Commission recommends:—

(*a*) to those observers who will determine the parallax in right ascension by means of observations of any of the three methods of measurement, either at isolated observatories, or by the coöperation of the observatories of Europe and America, to make the observations each morning and each evening, and to take advantage of all favorable atmospheric conditions to extend the observations to the greatest practicable hour angles.

(*b*) to observers who will determine the parallax by differences of declination in the northern and southern hemispheres, to so arrange the time of observations, that the instant corresponding to the mean of the times will not differ widely from the time of meridian transit of the planet at the southern observatory.

IV. It is necessary to take special series of photographic plates in the regions traversed by the planet Eros in order to determine the position of the comparison stars.

The reference stars for the determination of the constants of the plates should be determined by meridian observations.

V. Mr. Hartwig is charged to arrange a program for the heliometric observations of the planet.

VI. Mr. André and Mr. Prosper Henry are charged with the investigation of the atmospheric dispersion. M. Loewy will

communicate the results of these researches to the members of the commission and to the observatories participating.

VII. M. Loewy, Mr. Brown, Astronomical Director of the Observatory of Washington, and Mr. Bakhuyzen are charged with the duty of securing the execution of the different resolutions concerning micrometric and photographic observations.

The following reasons have led the special commission to propose the above resolutions to the General Conference:—

Resolutions I, II, III, and IV.—The committee is of the opinion that micrometric observations ought to be employed as well for parallax in right ascension as in declination, as it seems practicable to remove the difficulties involved in the determination of the parallax by micrometer observations in right ascension. These difficulties are of two kinds:

First—*The small field of view with the high magnifying powers employed with instruments of large size.*

The Commission finds the solution of this difficulty in the Resolution IV, prescribing series of photographic plates taken of the region traversed by the planet. The measurements will enable the relative positions of the comparison stars to be determined with extreme acuracy. If, on account of the rapid motion of the planet, the comparison star used in a morning observation is not found with the planet in the field of the telescope, another one can be selected, the position of which relative to the first, is known from the plates.

Second—*The difficulty of determination with exactness the motion of the planet.*

By means of Resolution II, the Committee hopes to obtain the motion of the planet, determined from day to day with such precision by means of a large number of observations, that the uncertainty of the daily motion of the planet between two successive observations in the evening and morning will have very small effect upon the resulting parallax.

It is for this reason that the Committee recommends in its Resolution III (*a*) the greatest possible continuity in the series of observations both morning and evening.

Resolution III (*b*) is necessary to give the observers of the southern hemisphere as great an altitude as possible for their observations.

Finally the Committee has considered the necessity of obtaining absolute positions of the planet, in view of the researches on the parallax which will be undertaken by the methods of celestial

mechanics. The series of plates taken in conformity with Resolution IV, will naturally furnish all the comparison stars desirable for the determination of the absolute positions of the planet.

Resolutions I, IV, VI.—The committee thinks that the photographic method offers no insurmountable difficulty. One of the objections which has been raised against this method, rests upon the uncertainty resulting from the form of the trail of the star or planets, according as the former or latter has during the exposure been kept immovable upon the cross wires. The committee hopes that the uncertainties arising from this cause can be evaluated, if they exist, by means of experiments, easily carried out, which will consist in making three exposures under the following conditions:

(*a*) Keeping the image of the planet on the cross-wires;

(*b*) Keeping the image of a guiding star on the cross wires;

(*c*) In giving to the telescope a motion in a contrary direction to that of the planet, but of nearly double its value. In comparing plates (*a*) and (*b*), it can be seen whether the mutual distances of the stars remain the same for all stellar magnitudes, or if it is necessary to apply a correction dependent upon the magnitude. At least analagous comparisons can be made by combining the three plates (*a*), (*b*), (*c*), in all possible ways. Several observatories have promised concurrence in these experiments, and it is important that they should be sufficiently large in number in order to ascertain the effect of the quality of the objective upon this phenomenon.

Another difficulty was considered, common to nearly all the methods of comparison, concerning systematic errors which may be introduced into the relative measures of the stars and the planet arising from atmospheric dispersion.

After the exchange of views of the members, and after having understood the methods proposed by Mr. Prosper Henry for evaluating the effect of influences of this kind, the committee appointed Messrs. Andrè and Prosper Henry to carry out the experiments for this object.

Such are the grounds of the resolutions concerning the parallax of the planet Eros. It may be asked if it is not necessary to draw up a complete programme for the combination of the observations of Europe and America. The committee has not thought it necessary to adopt such a program, for the reason that the daily motion of the planet ought to be determined directly, day by day, independent of all theory, and it is hoped with

great precision, and that the absolute simultaneity of measures will not be indispensable.

Thus each observatory, which decides to share in this great common work, will find itself in a position to determine the part which it will undertake. It is simply asked of the observatories to clearly inform the president of the executive committee as soon as possible of their intentions, in order that the general plan of the necessary distribution of the work, if there is occasion, may be completed.

The observatories which have already promised their concurrence are as follows:

Algiers, Athens, Bamberg, Bordeaux, Cambridge (England), Cambridge (U. S.), Cape of Good Hope, Catania, Cordoba, Edinburgh, Yerkes, Greenwich, Heidelberg, Leyden, Leipzig, Lyon, Marseille, Minneapolis, Mount Hamilton, Nice, Paris, Potsdam, Rome (Collegio Romano), San Fernando, Strassburg, Tacubaya, Toulouse, Upsala, Vienna (Ottakring), Vienna (Wàhring), Washington.

In sending the translation of the resolution for publication, it may make the situation clearer to give a few words of explanation. The paper submitted to the conference, proposed to make in Europe and America nearly simultaneous observations of planet referred to contiguous stars, selecting preferably those of a magnitude not greatly different from the planet's, but in all, nearness was considered of more importance than magnitude. The same stars would generally be selected by limiting the distance to from 60″ to 120″, and leaving the magnitude arbitrary down to the 11th or 12th. The relative positions of the stars used were to be determined by daily photographs of the region traversed by the planet. In a programme based on the proposal, the motion of the planet would be practically eliminated, as the difference of time would always be small, as also the star positions; if the same stars should not have been selected, the relative positions on the same plate could be obtained with extreme accuracy.

The modification proposed by the Conference is to make 1st at all observatories in Europe and America daily morning and evening observations at hour angles as large as practicable, using stars adjacent to planet, and without reference to approximate simultaneity. In this case there would seldom be a difference as large as three or four hours between evening observations here and following morning observations in Europe.

The motion of the planet to be obtained, regardless of theory, from daily observations, morning and evening.

2d, Observations in northern hemisphere for parallax in declination are to be made at approximate time of meridian transit in a southern observatory.

This plan is applicable for all the three kinds of measurements, photographic, micrometric, and heliometric.

SUPPLEMENTARY INSTRUCTIONS ON RESOLUTION 3 OF THE CONFERENCE.*—

In this paragraph by the *largest hour angle practicable* is to be understood an hour angle large enough to obtain a great parallactic displacement without bringing the altitude of the star below a certain limit, 20° for example.

As explained in the preceding circular, the conference thought that the daily motion of the planet could be obtained each day, independently of the parallax and of all theory. Nevertheless, on account of interruptions of the measures caused by atmospheric conditions affecting all the stations at once, it might happen that this element could not be deduced directly from the daily observations. To avoid such a case, and in order to refer to the same instant of time the measures made in America and Europe, it will be necessary to carry out in each observatory a supplementary series beside the two already indicated, of which the first corresponded nearly always ta an eastern hour angle, and the second which should always be a western hour angle. The third series would be made under the following conditions:

(*a*) In the observatories of Europe the supplementary series should be made about two hours before the second series (western).

(*b*) In the observatories of North America the supplementary series should follow by about two hours, the first series of measures (generally in the east) made at the beginning of the evening. By this plan the means will be provided of referring the measures of the observatories of America and those of Europe to the same physical instant by an interpolation simple and sure. In a great number of cases it will suffice to adopt an interval of time less than two hours between the two successive series of measures.

This plan is in accordance with that proposed by Mr. Brown of Washington in a note submitted to the conference, in order to as-

* Translation of the second circular of the International Conference; giving supplementary instructions concerning observations of Eros which ought to be begun at once, and also further details of the general plan of work.

sure simultaneity of observations in America and Europe.

WORK WHICH IT IS DESIRABLE TO BEGIN IMMEDIATELY.

1st. Micrometric observations of the planet with large equatorials by the ordinary method of comparison. These measures are designed to furnish precise position of the planet for the theory of its movement. It is much to be desired that some of these observations should be reduced and published immediately so that new corrections may be made to the ephemeris.

2nd. Special series of photographic plates in the region containing the apparent path of the planet, having for their object the determination of the relative positions of the comparison stars to which the planet will have been referred in the visual observations.

In order to gain time, to simplify the work and to carry out the project under the best conditions, it is not considered advisable to take the photographs of a given region at the same instant in which the planet is there. A reference to the ephemeris will show that there is great advantage in beginning this part of the work immediately.

The photographic experiments for the investigation of the effect of atmospheric dispersion and the trails of the stars referred to in the previous circular, should be carried on at the same time. But in this case, where the planet is not taken on the same plate, the photographic operation will be carried on as follows:

(*a*) Photograph of a portion of the apparent path under conditions equivalent to those laid down for short exposures in the photographic chart of the sky. For example, in making two successive exposures upon the same plate, one of six minutes, the other of two minutes, in such a way as to obtain for each star two images distant about 20″ from each other in declination. The plates of this series will be used for the determination of the relative positions of the comparison stars.

(*b*) Photograph of the same region, after giving to the instrument in reference to the diurnal motion an acceleration of one or two minutes of arc per hour.

It can be determined by examination, in accordance with the circular of August 3d, if the mutual distances of the stars on plate (*b*) have the same value as on plate (*a*), and from this comparison to deduce the systematic errors to be applied, if any. The plates of series (*a*) ought to lap over those of series (*b*), so that the same star will be on both plates.

The following rule is suggested for forming a table of equatorial co-ordinates of the center of the successive plates:

At the epoch of commencing the photographs adopt for the center of the first plate one of the positions given by the ephemeris and suitable for observation. Thus, for example, if it is desirable to mention the first of September the center of the plate should be taken at that point of the celestial sphere where the planet from its ephemeris will be on the 28th of November. To determine the center of the following plate calculate the right ascension and declination of the point situated about a degree distant from the preceding center and on the apparent path of the planet, and thus in succession for each plate.

In this way the area of the part common to two successive plates will never differ more than one-half of the total area; it will vary between .42 to .50.

The series for the determination of the parallax should commence about October 1st. A new circular containing various auxiliary tables and instructions for the observations will be distributed.

S. J. BROWN,
Professor of Mathematics, U. S. N.,
Astronomical Director.

PTOLEMY'S THEOREM ON THE APPARENT ENLARGEMENT OF THE SUN AND MOON NEAR THE HORIZON.

T. J. J. SEE.

FOR POPULAR ASTRONOMY.

The cause of the apparent enlargement of the Sun and the Moon near the horizon does not seem to be clearly understood, although the question was an old one even in the days of Ptolemy. An examination of the problem and of the theories given in the standard works on Astronomy can hardly fail to impress one with the desirability of a more satisfactory explanation of the phenomenon.

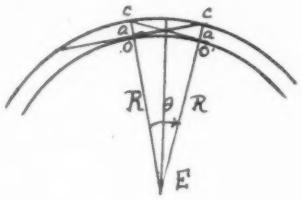
In the Almagest, Halma's Edition, page 9, Ptolemy says:

Ἀλλὰ γὰρ καὶ τὸ πρὸς τοῖς ὁρίζουσι μείζονα τὰ μεγέθη φαίνεθαι οὐχ η ἀπόστασις ἐλάττων ὑυσα ποιεῖ, ἀλλ' ἡ τοῦ ὑγροῦ τοῦ περιέχοντος τὴν γῆν ἀναθυμίασις μεταξὺ τῆς τε ὄψεως ἡμῶν καὶ αὐτῶν γιγνομένη καθάπερ καὶ τὰ εἰς ὕδωρ εμβληθέντα μείζονα φαίνεται, καὶ ὅσω ἂν κατωτέρω χωρῃ, τοσούτω μείζονα.

"For if the Stars appear to us larger when on the horizon, this is not because they are less remote from us, but on account of the moist vapor which surrounds the earth between our eyes and the

stars, and apparently enlarges them, just as things plunged into water appear to us the larger the deeper they are immersed."

Of course this explanation of Ptolemy is incorrect, yet it is quite as plausible as those given in text-books now in general use. In many such works we find the explanation that the Moon and Sun look larger on the horizon because of their proximity to neighboring terrestrial objects. Let us consider this question in a geometrical manner, such as the Greeks would employ if they had our knowledge of modern Physics.



Suppose o to be an observer on the surface of the Earth, $o\,o'$ an arc of the Earth's surface substending an angle θ at the center of the Globe, a the height of a layer of clouds in the terrestrial atmosphere (here somewhat exaggerated for the sake of illustration). And suppose an observer to ascend in a balloon to the upper surface of this stratum when the sky is clear; then he can see the station o' where the clouds disappear to the observer on the surface at o.

Now we have $\cos\theta = \dfrac{R}{R+a}$, and since $1 - \cos\theta = 2\sin^2\dfrac{\theta}{2}$,

we get $\sin\dfrac{\theta}{2} = \sqrt{\dfrac{a}{2\,(R+a)}}$.

But $\sin\dfrac{\theta}{2} = \dfrac{\theta}{2} - \dfrac{\theta^3}{2^3}\cdot\dfrac{1}{1.2.3} + \dfrac{\theta^5}{2^5}\cdot\dfrac{1}{1.2.3.4.5} - \ldots\ldots$

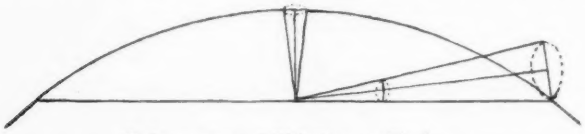
and when the angle is small, we may take the arc for the sine without sensible error, so that $\dfrac{\theta}{2} = \sqrt{\dfrac{a}{2\,(R+a)}}$.

If the height of the clouds be a little over a kilometer, say $\dfrac{1}{5000}$th of the Earth's radius, as frequently happens, the second term will reduce to $\sqrt{\dfrac{1}{10002}} = \dfrac{1}{100}$, nearly. Thus the station at o' removed from o by the angle θ is one-fiftieth of Earth's radius distant, or 127.6 kilometers, and the angle θ is 1.°15.

Thus, neglecting refraction for the sake of simplicity, an observer at o could see clouds just on the horizon at o', 127.6 kilometers away, when they pass over his head at an elevation of 1.276 kilometers, which is probably a fair average of the height of

most rain-bearing clouds. The observer sees these clouds going over daily, and becomes conscious of the fact that he can see much further near the horizon than overhead; and the result is that he conceives the sky unconsciously to be made up of strata such as the clouds float in — the vertical height being small compared to the horizontal distance to which he can penetrate.

If the clouds overhead are distant 1.3 kilometers, he ought theoretically to be able to see them at a distance of more than 120 kilometers. Practically he is accustomed to view them near the horizon, at a distance of some ten or twenty kilometers, as few persons make an effort to see clouds till they become conspicious objects near by. The concrete result is that almost all persons from the continued impressions of nature from childhood, come to view the dome of the heavens as having a horizontal extension ten or twenty times its vertical height. Those who have



Enlargement of Objects near Horizon.

a more limited view, give the horizontal extension of the sky as only three or four times that of the vertical. Now the mind fixes the Sun and Moon on the visible surface of this flattened dome, whether they be near the horizon or high in the heavens. And as the angular aperture of the luminous disc is the same without regard to the distance of the vault into which it is projected, the mind involuntarily enlarges it strictly in proportion to the distance at which it is supposed to be. Thus near the remote horizon it may appear to have a diameter 3 or 5 or 10 or 20 times that which it has when floating in the sky overhead.

The enlargement is purely psychological, due to the deceptive shape of the celestial sphere continually produced upon our minds from childhood by the visible effects of clouds in the atmosphere. And as our habits of mind lead us to place the base of the dome of the heavens at a greater distance, while the arch overhead is quite near by, the eye is too accurate and faithful a guide to the mind, to fail to convey the impression of a rising luminary of immense extent, while overhead, the impression is that of a body of greatly diminished magnitude.

From these considerations it follows that while Ptolemy's explanation of the Moon's enlargement as being due to the envelope of vapors through which the body appears, is incorrect, it yet contains an element of truth in ascribing the illusory effect to the depths of vapor in which the disc is projected.

WASHINGTON, D. C., 1900, August 6.

REPRESENTATIVE STELLAR SPECTRA BY SIR WILLIAM HUGGINS AND LADY HUGGINS.

W. W. PAYNE.

In our last number we did not complete what we wished to say about Vol. 1, of the publications of the Sir William Huggins' Observatory at Tulsehill, London, England. But before continuing our brief account of this important work, we should make a correction in our statement of the price of the book which is given, in the second line from the bottom of page 327, as $5. The price, as announced in a circular just received from Messrs. William Wesley and Son is £1 5s net, or $6.25, and not $5, as there printed.

It was in 1866, '67 and '68 that Dr. Huggins discovered, in three of the faint comets of those years, that part of the light emitted from them belonged to the comets themselves, and that the light of the comet of 1868 gave a spectrum consisting of three bright flutings. These new and intensely interesting facts awakened great expectations for the study of the much brighter comet which appeared in June 1868. As the telescope armed with a spectroscope was turned on this comet, the spectrum of three bright bands or flutings again appeared, each alike falling off in brightness toward the violet end of the spectrum. The positions of these bands were carefully measured from the bright and sharp edge on the red side, and to the surprise of Dr. Huggins they were found to agree, in position, with three similar flutings in the brightest parts of Carbon. For the first time, Dr. Huggins was privileged to see the fluted spectrum of this comet confronted with the spectrum of olefiant gas, and to find in this comparison a full and exact confirmation of the nature of the substance from which proceeds the greater part of the light of those comets which give spectra like these just described.

It will be remembered that the relation of comets and meteoric swarms, at this time, was attracting much attention by the discoveries of Newton of Yale, Adams of England and Schiaparelli of Italy, and so it became easy and natural to make a study of meteorites to find out what gases might be found in these sky-stones in an occluded state. As a result it was soon known that meteorites contain carbonic oxide, carbon dioxide and that many of them carry a large percentage of hydrocarbons. It has been later observed that some give spectra containing the three bands like those seen in the base of a candle flame, and it is now an accepted fact that the greater part of the light of comets is due to

the fluted spectrum of carbon.

In this connection Dr. Huggins calls attention to some additional knowledge in respect to the light of comets which was gained by the aid of photography. In 1881, for the first time, suitable photographic plates were in the hands of astronomers, and the appearance of a bright comet that year, made it possible to examine its light in the invisible region of the spectrum toward the violet. Of this photograph Dr. Huggins says: "The plate contained an extension and confirmation of my earlier observations by eye. There were the combined spectra of two kinds of light—a faint continuous spectrum crossed by Fraunhofer lines which showed it to be reflected solar light. Upon this was seen a second spectrum of the original light emitted by the comet itself. This spectrum consisted mainly of two groups of bright lines, characteristic of the spectra of certain compounds of carbon. It will be remembered that my earlier observations revealed the three principal flutings of carbon as the main feature of a comet's spectrum in the visible region. The photograph brought a new fact to light. Liveing and Dewar had shown that one of these bands consisted of lines belonging to a nitrogen compound of carbon. We gained the new knowledge that nitrogen as well as carbon and hydrogen exists in comets. Now, nitrogen is present in the gas found occluded in some meteorites. At a later date Dr. Flight showed that nitrogen formed as much as 17 per cent of the occluded gas from the meteorites of Cranbourne, Australia."

So much has been said of the splendid work of Dr. Huggins in these earlier years of the so-called new astronomy to bring to the attention of our readers the large and important part due to his labors in its rise and rapid progress. Those who are acquainted with the history of practical astronomy between the years 1865 and 1885 especially, very well know that to Dr Huggins chiefly belongs the credit of outlining the large and grand foundation of the new astronomy as distinguished from the old, by all writers in science in later years. Those who are not familiar with the history of the new methods during, and since, the period named above, will find much information in the pages of this new book in regard to method and result in astronomical work which occupy the attention and the energies of foremost astronomers in all parts of the world, even at the present time.

Before closing this brief review, it may be profitable to the

reader to have a short account of this new book as a whole, that he may gain thereby a more complete idea of its entire contents, including the work of the authors to the present time, as well as that referred to particularly in what precedes.

The contents of this volume is divided into eight chapters; the first treats of the history of the Observatory, and of the work done therein; the second is a list of the published papers on the work of the Observatory; third, description of the methods of taking the photographs of the stellar spectra; fourth, description of the spectroscopes in use in the Observatory; fifth, description of the automatic arrangement by which the necessary breadth was given to the stellar spectra on the photographic plate; sixth, discussion of the evolutional order of the stars, and the interpretation of their spectra, treated under the heads,

(1) Of the types of stellar spectra,
(2) Original differences of stellar constitution,
(3) Classification of stellar spectra,
(4) Physical and chemical interpretation of stellar spectra by means of terrestrial spectra observed in the laboratory.

Seven, description of the plate of historical spectra; and eight, preliminary discussion of the stellar spectra of the plates.

Following the contents are the twelve beautiful plates mentioned in the previous article. The first is spark spectra showing effect of density on the relative intensities of the lines of calcium. Second is historical spectra; third gives spectra of the Sun and the Great Nebula of Orion, of A, of θ Orionis, of the Sun and Nova Aurigæ. Four gives Spectra of β Lyræ and helium enlarged 4¾ times, of Bellatrix, oxygen and nitrogen, of Bellatrix and helium, of Rigel and helium. Five presents spectra of Rigel, sillicum and titanium enlarged 4¾ times, of α Cygni, sillicum and titanium, of α Leonis, of γ Lyræ, of γ Andromedæ, of α Lyræ. Six shows two spectra of Sirius, enlarged 4¾ times, of Castor (fainter star only), of α Aquilæ, of Procyon and of γ Cygni. Seven gives spectrum of γ Cygni, enlarged 4¾ times, of the Sun and Capella, of Arcturus, iron and calcium, of γ Andromedæ and of Betelgeuxe. Eight, enlarged 15 times, is the spectrum of β Lyræ, of Bellatrix, of Rigel and of α Cygni. Nine enlarged 15 times gives spectra of α Leonis, of γ Lyræ, of Serius, of Castor, and of α Aquilæ. Ten, enlarged 15 times, shows spectra of Procyon, of γ Cygni, of Capella and the Sun, of Arcturus and of Betelgeuxe. Eleven presents spectra of the component stars of Castor, of the component stars γ Andromedæ, and of the component stars of β Cygni.

Twelve gives the spectra of the component stars of Cor Caroli, of the component stars of α Herculis, and of the component stars of γ Leonis.

From such an outline the variety of work and the detailed extent of it at once appear. The stars chosen are typical ones, and the methods employed by these distinguished astronomers were among the best now known, and hence nothing less than quick and notable results would follow their pains-taking labors, even in laying the broad foundation of the new astronomy that the scientific world now so much enjoys in the end of the nineteenth century.

TOTAL SOLAR ECLIPSE OF MAY 28, 1900.

M. MOYE.

For Popular Astronomy.

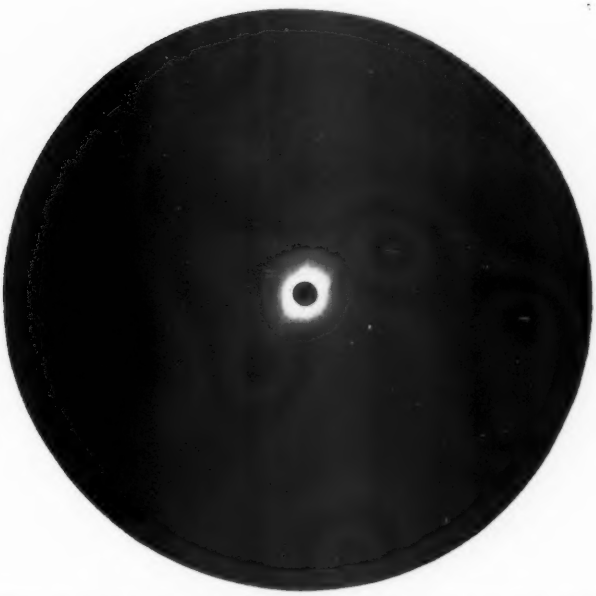
Being very desirous to observe this beautiful phenomenon, I went to Elche, near Aliconte, (Spain), a pretty town not distant from the central line of totality. At first I had some fears because of ominous clouds and rain, but on the 27th the sky became perfectly clear and the eclipse was observed without the slightest trace of a cloud.

Besides photographs of the corona made in connection with the Montpellier University Expedition (results of which will be separately published in *Comptes-Rendus de l'Académe des Sciences*), I have made the following scientific observations, especially on the Shadow-Bands and a tolerably exact sketch of the corona as seen to the naked eye. (See plate XIV.)

Shadow-Bands.—For the observations of these bands, I was seated on a corn-threshing floor, perfectly levelled and commanding a wide view of land. About three minutes before totality, I saw the shadow-bands. They were regular, with the appearance of sinusoidal curves, not clearly defined, but greyish and faint on the ground. However, their intensity was sufficient to get the attention of two Spanish policemen who were at my left. The width of the bands was two inches apart when it was about 1 or 1¼ foot. Their motion uniform, it seemed, was as rapid as a man walks.

At first the motion was precisely the same direction of east and west. But one minute before totality, I saw a remarkable phenomenon (not observed before, I believe). Beides the first system already described, was seen suddenly a second system of

PLATE XIV.



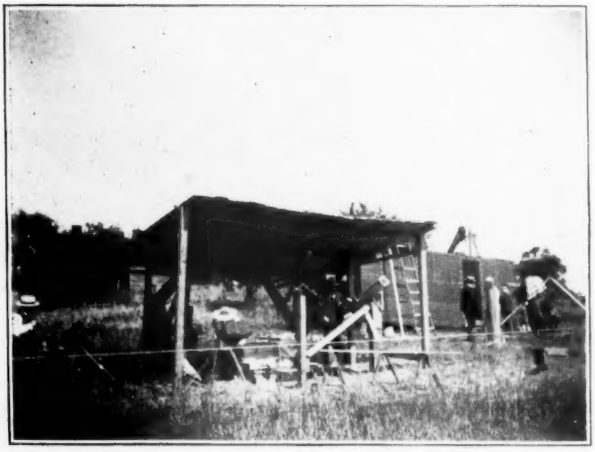
THE SOLAR CORONA, MAY 28, 1900, WADESBORO, N. C.

Photographed by David E. Hadden, 2½ inch Portrait Lens, 18 inches focus. Exposure about 5 secs.

DRAWING OF CORONA MADE NEAR ALCANTE, SPAIN, BY M. MOYE, MONTPELLIER, FRANCE, MAY 28, 1900.

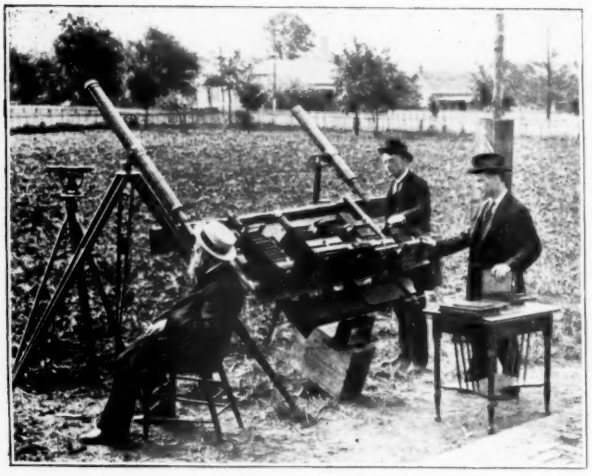
PLATE XV.

Total Solar Eclipse, May 28, 1900.



British Astronomical Association Station, Wadesboro, N. C.

Photographed by H. E. Hadden.



St. Louis University Station, Washington Ga.

Rev. C. M. Charroppin, at telescope.

bands, showing the same general appearance, but the motion was distinctly in the opposite direction, viz: from west to east.

I have satisfied myself of the reality of the thing, which was testified to after totality by several other persons near. I must say that the wind, moderate in force, was blowing during all the eclipse from the same direction, east south-east.

Appearance of the corona.—To the naked eye and in the opera glass, the Moon was perfectly black and it was surrounded by a circle of silvery white almost dazzingly bright, and resembling the classical drawings of an Annular Eclipse. This was the inner corona. At the right and left of the Sun, were two immense streamers, pearly of tinge, tolerably bright and fading away gradually on the edges. They were on the ecliptic or very near it, their length was two or three solar diameters, the western streamer was noticed almost near Mercury, at 2° from the Sun. The original form of the streamer was very conspicuous, each seemed like two curved rays with a central rift. At the Sun's poles were only short and faint plumes, a typical form of a minimum year.

No star, (except Sirius) was seen, but Mercury was bright, as Venus at the beginning of the twilight. It is needless to say that Venus was very bright over our heads.

General Notes. During totality the sky was dim, the blue become an ashy grey; round the horizon a large zone of a golden yellow hue, with rosy and lilac streamers, producing a very artistic and a beautiful view.

The landscape was as if draped in a dull leaden grey, the colors faded from objects and the appearance was grand and rather sorrowful.

The falling temperature as totality drew near, was very striking and the coolness was such as to become rather unpleasant. The thermometer (Centigrade) fell from 26° to 20° in the shadow.

The obscuration of the scene was not intense, all objects were distinctly seen, as the divisions of a watch; a newspaper could be read without artificial light; the general illumination was much greater than the light of the Full Moon.

UNIVERSITY AT MONTPELLIER, (FRANCE),

June 16, 1900.

TOTAL SOLAR ECLIPSE MAY 28, 1900.

W. W. PAYNE.

Something more can be said about the results of the observations of the last total, solar eclipse in addition to what was given, last month, by Dr. H. C. Wilson, of Goodsell Observatory, who was the astronomer of the party from Carleton College that observed the eclipse at Southern Pines, North Carolina.

In his account reference was made to the work of his party particularly, and the party from Guilford College. He gave a description of the eclipse, the corona, the observations of the contacts and some interesting and useful remarks about other stations near, such as Pinehurst, Barnsville, Winnsboro, Griffin and Wadesboro. At some of these stations were parties containing distinguished astronomers from home, and some from abroad. The names of most of them are given in the paper referred to, and something is said of the particular astronomical work that each had planned to do. Two illustrations accompany the paper; one is a picture of the observing station of the Carleton College party, and the other is a reproduction of one of the negatives taken with the eight-inch photographic telescope during totality. The cut does not give nearly all the detail which the original negative shows, either in the inner or in the outer corona. It is very much to be regretted that we have no means of reproduction which will faithfully bring out nearly all that the original negatives show. Hence, we have to be satisfied with that which can be secured, and try to make up what is lacking in verbal description.

The first thing that may come to the minds of thoughtful readers is, what have astronomers learned from the results of the total eclipse of May last? The day was almost a perfect one throughout the entire path in the United States, and the number of observing parties was large at different points along the line of totality all the way from the Gulf of Mexico to the Atlantic Ocean. Surely from such a favorable opportunity some satisfactory results must have been gained. If we notice Mr. Chas. Burckhalter's work which is presented in plate XIII the results of a new method of exposing plates to photograph the inner and outer corona at the same time will be seen. Mr. Burckhalter sent us six positives in the form of lantern slides. The reproductions are five and six in the series, and show very plainly the difference between an exposure which is controlled and one that

is not controlled. No. 5 is the exposure of a plate for eight seconds of time, in the ordinary way, both for the inner and for the outer corona, and it is seen that the effect is about the same as that which is observed in any of the good photographs of the corona taken during the last eclipse. No. 6 shows the application of a piece of apparatus designed to control and adapt the time of exposure of a plate, so as to give less time to the bright, inner corona, and more time to the outer faint part, and thus to avoid over exposure of the former, and under exposure of the latter when it is desired to photograph both parts at the same time, on the same plate. Evidently the difference between the two pictures is marked, and largely in favor of the controlled method in securing details in all parts of the corona at the same time in a single exposure. These pictures were both taken at the same time, and the total exposure of each was eight seconds. The figures at the top of No. 6 show very closely the actual time of exposure of the plate at the respective distances in arc from the center, indicated by the figures of the upper line. In other words at a distance of 16′ from the center, the time of exposure was $0^s.04$; at 32′ it was $1^s.76$ and at 110′ it was $8^s.00$. The semi-diameter of the Sun on May 28, was nearly 15′ 47″, that of the Moon at the same time was 15′ 58″, nearly. From these figures it will be readily understood how the time of exposure was related to the corona and the limb of the black Moon in the short period of totality. It is also evident why the time of the total phase was so short which was a disadvantage, in view of the work, but also a small advantage in revealing the inner corona when the obscuration was greatest.

Mr. Burckhalter speaks confidently of the time of exposure in the different parts of the corona which was under control and says that they are not simply approximate, but they are very close to the values given, and certainly within one fortieth of the values named.

Astronomers who are practical photographers will certainly be interested in this new piece of apparatus, designed some time ago by Mr. Burckhalter but who has not before had opportunity to give it a trial in eclipse work.

Another feature of this eclipse of some interest was that of the shadow bands. As noticed in the article above referred to last month, care was taken at the station in Southern Pines, to observe this phenomenon and the results are given on page 303. In an article, elsewhere published in this number, by Professor M. Moye, of the University of Montpellier, France, interesting facts

about the same phenomenon appear. They are so different from those noted by the observers of the Carleton College party and others at the same station, that it has seemed desirable to call attention to these observations. Both seem to be definite, and to have been carefully made in all respects, but the differences of velocity, width of shadow and direction of motion are considerable. It might be possible to bring these observations into harmony if we knew more of the nature of this phenomenon and the circumstances of observation at the two stations which may differ in some important particulars.

Another point of some interest, which may be spoken of more fully later, is the relation of the form, and some other features of the corona, to the 11-year cycle of the sun spots. Some astronomers have thought that such a relation exists, and they have been studying total eclipse of recent date to ascertain, if possible, the evidence on which such a supposition rests. It is claimed that in or near the maximum part of the period, solar eclipses show a correspondingly large and active corona, as indicated by the number and length of his streamers, its rifts and its varied and complex structure. In the inner corona and about the polar regions in the eclipse of 1889 a most beautiful display, probably of electrical and magnetic lines of force were seen by many observers. Those who gave special attention to a visual study of the corona of the eclipse in May last, say that the two have points of resemblance in the particulars just mentioned. On the whole, the supposition is a reasonable one. If the corona is due to the condition of the photographic regions, we ought to expect changes in its visible structure when the solar surface is most active. Since this is especially true of the equatorial regions of the Sun as compared with those of the polar, at all times, it ought also to be true of the equatorial regions when the greatest differences of activity exist there. More will be said later of the work of professional astronomers when the results of the same are more definitely known.

This brief account should not close, for the present, without reference to the work of some of the amateurs. It would be profitable to say much of what was done by this large and enthusiastic class of observers who occupied many stations in the line of totality, and who obtained useful results by the aid of small instruments. The articles for the papers, the many photographs of the corona and the illustrated pamphlets that have come to hand plainly show this. One of the neatest of these pamphlets was by David E. Hudden of Alta, Iowa, which is a

PLATE XVI.

Total Solar Eclipse, May 28, 1900.

Eclipse Station at Wadesboro.

H. E. Hadden, with 4-inch telescope.

Eclipse Station at Wadesboro

1. Thos. Lindsay, Toronto.
2. J. L. Campbell, Wabash Coll., Ind
3. C. A. Young, Princeton.
4. Prof. Brackett, Princeton.
5. Prof. Libbey, Princeton.

[Numbers read from left to right.]

fitting souvenir of his trip to Wadesboro, N. C. The illustrations of some of our plates were taken from this booklet; those showing Mr. Hadden at his 4-inch telescope, the location of the British Association Station and some observers with Professor Young in front of the temporary photographic house. The whole pamphlet consisting of a popular account of the eclipse is interesting reading, and the many photographs sent therewith are excellent.

Chas. P. Howard who observed in connection with the Trinity College party at Winston, N. C., has a good report of his observations and a drawing of the corona in the Trinity College Bulletin, No. 2, 1900. He says the conditions for work at Winston were favorable in a rare degree.

Professor C. M. Charroppin of St. Louis sent us very good photographs of the eclipse by small cameras. One in particular which showed streamers nearly three diameters of the Moon. In one of our plates his arrangement of a number of cameras is shown. Professor Charroppin is an excellent photographer. E. N. Fought, of the "Herald" Carlisle, Pa., who has written somewhat for this magazine, on popular themes, favored us with a full accout of the work of the Dickinson party which observed at Pungo, Virginia. A large Rowland concave grating was used in photographing the spectrum in the eclipse work of this party. We would speak of these and other parties from which notices have come, but space is wanting for it at this time. Later we will give the results of many amateur who have reported contact observations at stations in, and outside of, the path of totality.

ON THE PROPAGATION OF THE TIDAL WAVE UPON THE TERRESTRIAL SPHEROID REGARDED AS SOLID AND COVERED BY OCEANS OF UNIFORM DEPTH.*

T. J. J. SEE.

FOR POPULAR ASTRONOMY.

The aim of this short paper is merely to draw attention to certain simple phenomena connected with the tide-wave. The oscillations of the particles of the sea are very imperfectly set forth in every work with which I am acquainted, and as many elementary works treat the subject in an erroneous manner, I have been

* Read before Section *A*, American Association for the Advancement of Science, New York, June 27, 1900.

led to think that a brief geometrical explanation of the chief phenomena would be welcomed by students of Physical Science.

It is shown in works on waves† that the motion of any particle may be defined by the relations

$$\left.\begin{aligned} x' &= x + \varphi\,(x,\,t) \\ y' &= y + \psi\,(y,\,t) \end{aligned}\right\} \qquad (1)$$

where x and y denote the coördinate of the particle when undisturbed by wave motion, and t the time reckoned from some arbitrary epoch. The functions $\varphi\,(x,\,t)$ and $\psi\,(y,\,t)$ represent periodic oscillations about a mean position, which may be best represented by cosines of angles.

$$\left.\begin{aligned} x' &= x + \xi\,(x)\cos\,(nt - vx) \\ y' &= y + \eta\,(y)\sin\,(nt - vx) \end{aligned}\right\} \qquad (2)$$

It is shown that these equations* may always be transformed into

$$\left.\begin{aligned} \Xi &= A\left(e^{\frac{2\pi\gamma}{\lambda}} + e^{-\frac{2\pi\gamma}{\lambda}}\right)\cos\,(nt - vx), \\ \Upsilon &= -A\left(e^{\frac{2\pi\gamma}{\lambda}} - e^{-\frac{2\pi\gamma}{\lambda}}\right)\sin\,(nt - vx) \end{aligned}\right\} \qquad (3)$$

where γ is the depth of the fluid, and λ is the wave length. When the waves are long compared to the depth of the sea, as in the case of the tide-wave.

$\frac{\gamma}{\lambda}$ is small, and we may put

$$\left.\begin{aligned} e^{\frac{2\pi\gamma}{\lambda}} + e^{-\frac{2\pi\gamma}{\lambda}} &= (2 + \delta) = a', \\ e^{\frac{2\pi\gamma}{\lambda}} - e^{-\frac{2\pi\gamma}{\lambda}} &= \left(\frac{4\pi\gamma}{\lambda} + \delta\right) = b' \end{aligned}\right\} \qquad (4)$$

where δ, a', b', are very small quantities. By means of equation (4) equation (3) thus gives $\frac{\Xi^2}{a'^2} + \frac{\Upsilon^2}{b'^2} = 1$. which is the equation of an ellipse. As b' is very much smaller than a', the Ellipse is obviously very eccentric, or the horizontal motion is very much larger than the vertical motion, as is well known in the case of tides.

It is shown in works on the Mathematical Theory of Tides that the first and chief term of the tide-generating potential is

† "On the General Theory of Tides and on their Secular Effects upon the Figures and Motions of the Heavenly Bodies," by the author; or Airy's "Tides and Waves."

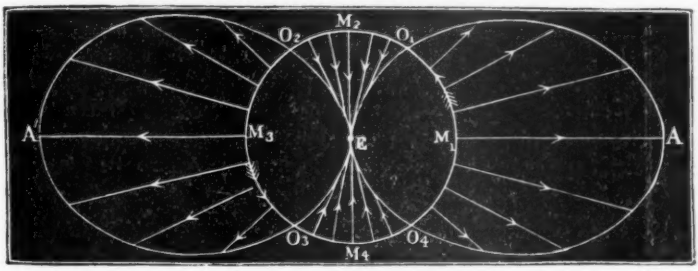
$$V = \frac{3}{2}\frac{m}{\rho^3} r^2 \left(\cos^2\omega - \frac{1}{3}\right) \qquad (5)$$

Where m is the Moon's mass, ρ its distance, r the radius of the Earth, ω the geocentric angular distance of the disturbed particle from the Moon.

If we differentiate this expression relative to any direction, we shall get the forces which disturb the particle relative to the center of the Earth. The whole theory of the tide is based upon the development and extension of this formula. If we differentiate V with respect to ω and put $\frac{\partial V}{\partial r} = 0$, we shall have the condition that the force is entirely horizontal, and does not tend to elevate the water.

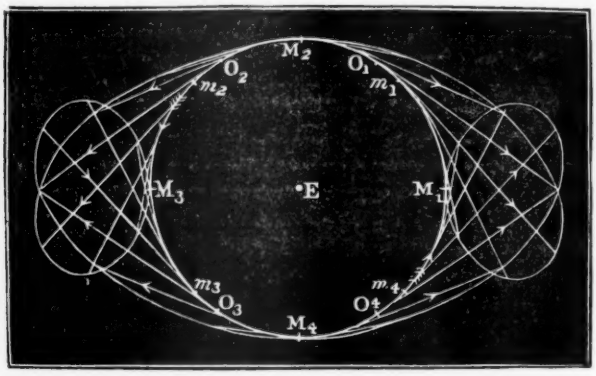
This gives $\cos^2\omega - \frac{1}{3} = 0$, or $\omega = 54.°75$. Thus in the Hemisphere under the Moon, from $\omega = 0$, to $\omega = 54.°75$, the forces tend to elevate the water; then in a zone from $\omega = 54.°75$ to $\omega = 121.°2$, the water is under a depressing influence; from $\omega = 121.°2$ to $\omega = 180°$ the forces again tend to raise the water.

The following figures illustrate the radial and tangential forces which act upon the water.



The rise of the water is due principally to the action of the horizontal forces, as the vertical forces are of little effect against gravity. The ebb and flow of the tide is chiefly a horizontal oscillation of the water, the fluid either side of the point of highest elevation having run towards that point to raise the level, and having run away from both sides of the lowest depression to produce the drop. Let us now assume the Moon to move in the Celestial Equator and imagine an aqueous canal of uniform depth encircling the equator of the Earth, and let us then inquire in what manner the water is running in the different parts of the

canal at any instant when tides are generated in the fluid by the disturbing action of the Moon. Since in case of the semi-diurnal tides there are two approximately equal tides each day, it is evi-



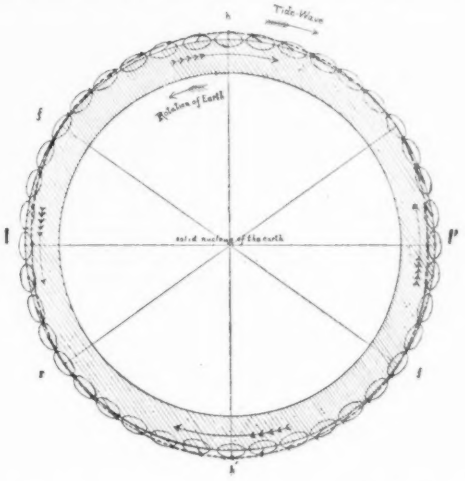
dent that the canal will be divided into four parts; first, an elevation extending over an arc of 109°.5; second, a depression extending over 70°.5; third, a second elevation extending over 109°.5; and fourth, a second depression extending over an arc of 70°.5.

Suppose we draw around the accompanying equatorial section of the earth a series of ellipses representing the oscillations performed by the particles, and indicate in each ellipse the approximate radius vector and phase of the particle at a given instant. To render these ellipses visible to the eye they are necessarily made much rounder than the paths actually described by the particles of our seas. In the figure let h and h' be the places of high water, where the flow is exactly horizontal and in the direction of the propagation of the tide-wave; let f and f'* denote the two points where the water is falling most rapidly, and the motion of the particles is upward; and finally let l and l' be the two points where the water is lowest, and the motion directly contrary to the direction of the motion of the tide-wave. The arcs between these points are as follows:

$$hf = 54.7°$$
$$fl = 35.3°$$
$$lr = 35.3°$$
$$rh' = 54.7°$$

* The prime (′) is omitted in cut; should appear with f on lower right hand.

These arcs are deduced from the tide-generating potential, and represent the parts of the circumference over which the tide-generating forces tend to elevate or depress the water. Assuming



that the fluid in the equatorial canal will respond to the forces acting upon it, we have inserted in the figure a series of ellipses with radii vectores showing the phase of the particles in the several regions, and also arrows showing the direction of the revolution of the ellipses, as the earth rotates and the tide-wave advances westward. A slight displacement of each particle in the direction of the advance of the tide-wave is seen to account for the motion of the shape, and in this way the major axis of the figure of the canal appears to revolve relative to the earth. The figure thus appears to explain the progress of the tide-wave in perfect accord with the preceding analytical theory. It will be seen that on each side of *r* the water is running toward that point over a total arc of 180°; 109.5° of the arc being on one side of *r* and 70.5° on the other; while on the other side of *f* the water is receding over similar arcs.

At *l* or *l'*, the center of the arc of 70.5°, the motion is exactly horizontal and backwards; at *h* or *h'*, the centre of the arc of 109.5°, the motion is exactly horizontal and forwards. It may be observed that the *tide-wave moves in the direction of the flow of the larger of the two arcs which contribute to raise or lower the water at r or r', f or f'.*

This consideration holds for the *propagation* of a *free wave*,

such as the tide-wave becomes when once generated. *Forced waves* are of the same general character, but may be propagated at any velocity consistent with the action of the generating forces. Our actual tides are summations of a series of free and forced waves, superposed by the recurring periodic forces of the Sun and Moon; and as the ocean is of variable depth, the two series of waves are propagated at very unequal rates. If we consider the forced state of the sea following the Moon's transit, by a certain interval, it will correspond approximately to the foregoing figure of the tide wave.

NEW FORMS OF TELESCOPES AND OTHER OPTICAL INSTRUMENTS.

W. B. MUSSON.*

FOR POPULAR ASTRONOMY.

There have recently appeared in the newspaper and scientific press communications dealing with a new form of telescope, the fundamental principle of which consists in attaining the achromatism of a large object glass by the interposition of a small concavo-convex lens, silvered on the back. The curvatures of the small correcting negative lens, with its internal reflecting surface being so proportioned as to cause its negative chromatism to correct the positive chromatism of the object glass more completely than has yet been attained, at the same time at a much less cost and with a shorter tube.

It has recently been announced that Professor Schupmann of the Technische Hoch Schule at Aix-la-Chapelle in Prussia, on July 30, 1897, applied for, and obtained in the United States (under Letters Patent No. 620978, dated March 14th, 1899,) a patent on such an instrument as is aboved described under the name of "Medial-Fernohr." Among other things, it is claimed that one of the advantages of the telescope is that single crown glass lenses alone may be used. Prof. Schupmann, it is also announced, has published a book on the subject.

Under the circumstances, and in defence of the interests of two of its members, Messrs. Z. M. and J. R. Collins, the Astronomical Society of Toronto, thinks it proper to intervene for the purpose of laying before your readers certain facts not hitherto published, and which may tend to place the alleged new invention in a different light.

*Secretary Toronto Astronomical Society.

In 1893 the Messrs. Collins constructed a Telemeter of their own design in which a modified form of dialyte objective was used for the purpose of shortening the tube and amplifying the focus. As a further result of their studies they came to the conclusion that certain principles employed in their Telemeter might be advantageously used in a telescope combining some of the properties of a refractor and a reflector. In the summer of 1896, they completed and exhibited to a few friends and a number of members of this Society an instrument of 4 inch aperture, 2 ft. in length and 4 ft. focus which they called the Monoplane achromatic Telescope. This instrument performed admirably, photographs being taken with it. On the suggestion of the Messrs. Collins, confidential communications were, in the spring of 189 7, addressed to Lord Kelvin, and to Professor J. A. Brashear, of Alleghany, Pa., and Dr. H. C. Vogel, Potsdam, Prussia. To these gentlemen were also submitted drawings as well as descriptions of the fundamentals of the Monoplane combination. On the data before him, Lord Kelvin declined, however, to express a conclusive opinion; Professor Brashear, while not committing himself to the principle involved, suggested that an eight-inch telescope of high quality should be constructed and tested. In his first communication, Dr. Vogel, who stated that he had shown the invention to his assistants, unsparingly condemned the telescope, but after a letter, explaining to him an error in the figures first supplied him, together with enlarged explanations, Dr. Vogel then said the combination appeared to him in an entirely new light, and with the figures then before him he found the correction for chromatism "to be more complete indeed than is the case with the ordinary achromatic objective."

As a result the construction of an instrument of 3 inches aperture was proceeded with—the late President, Mr. Arthur Harvey, F. R. S. C., and Mr. John M. Martin joining them with a view to furthering its completion. The development, however, of an important feature of the combination (not mentioned in the communications referred to and not included in Professor Schupmann's patent specifications) delayed the construction of the second instrument and it was not until this was nearly completed that Professor Schupmann's patent proceedings became known.

The point which the Society wishes to make is that, so long ago as the early part of 1896, a telescope embodying the essential features of that described by Professor Schupmann, was constructed and tested in Toronto. In each of two annual ad-

dresses to the Society, delivered in January in each of the years 1896 and 1897, Mr. John A. Paterson, M. A., President, referred to the instrument, and claimed for the Society the credit of having members sufficiently skilled in optics to produce a combination of lenses composed of one kind of glass, which could be used for telescopes, microscopes and cameras, greatly cheapening the cost and reducing the size of these instruments.

In the address of 1896 he says: "The Collins brothers have proved their ability in the figuring and polishing of parabolic mirrors for reflecting telescopes, and recently they have invented a telescope of an entirely new design, which will attain a maximum result at a minimum cost, measuring only half the length of the ordinary design, bearing at the same time the same magnifying power and possessing the virtue of achromatism by the use of two lenses, both of crown glass. By changing the relative position of the chief lenses the achromatism can be undercorrected or over-corrected. A short achromatic telescope with two lenses of the same material sounds like an impossibility.

In the address of 1897 he says: "Two of our most earnest members, the Collins Bros., are still developing their new Monoplane achromatic telescope. It is one of eight inches aperture, having a new form of objective of one kind of glass. Mounted equatorially it delivers an image of a celestial object in front of the eye-piece in dimensions equivalent to a focal length of forty feet, although the extreme length of the instrument complete is but four feet. It is able to correct for spherical aberration as well as chromatism and also for the "Schaeberle" aberration that must necessarily exist in the ordinary refractor of great angular aperture. Dr. H. C. Vogel, of the Astrophysical Observatory, Potsdam, after a mathematical analysis of the correction for achromatism, says: "A workable objective is now shown which, as the reasoning proves, unites in an excellent manner the rays from red to violet, better indeed than is the case with an objective of the usual construction." It may be added that the same principle may be applied to the microscope.

It may be added that upon this subject the Society is preparing a special report, which will include copies of the correspondence which passed between the Society and the authorities referred to.

In justice to the Messrs. Collins, I am to ask you to be so good as to find room in your valuable paper for this communication.

THE PLANET JUPITER.*

G. W. HOUGH.

1. The surface density of the planet Jupiter is presumably less than one-half that of water. The experiments made during the past twenty-five years in the liquefaction of air and gases enable us to imagine a plastic medium of the probable density of the planet.

If, then, the objects we observe are located at different levels in this medium, it would enable us to understand better why spots in the same latitude give different rotation periods.

2. The great Red Spot, 27,000 miles long, 8,000 miles wide, and possibly as deep as it is wide, drifts in both longitude and latitude.

It is the most stable of any marking seen on the disk. Its visibility may depend on its greater or less submergence beneath the surface, and its rate of drift (rotation period) may also be due to the same cause.

3. The rotation of the whole surface of the planet, on which spots or markings have been observed, is performed in $9^h\ 55^m$ to 56^m. The true rotation of the planet, however, may be slower than the longest rotation period hitherto observed, in which case all objects would drift in the same direction. My observations during the past twenty years extend from $+ 37°$ to $- 38°$ of jovicentric latitude. Very few rotation periods have ever been determined outside these limits.

4. The rotation period is not constant for any latitude, but usually varies with the time.*

5. There is apparently no direct connection between latitude and rotation period, as is sometimes alleged.†

6. The rotation periods determined from spots or markings lying in the same latitude and at the same opposition may differ *inter se* 30 seconds or more. Hence the conclusions deduced by some observers for various permanent currents *on the surface of* the planet are based on insufficient data.

7. In the equatorial region from $+ 11°$ to $- 8°$ of jovicentric

* Vide Astronomische Nachrichten, 3354.

† Vide Popular Astronomy, February 1899, Table of Rotation Periods.

* This brief article contains the conclusions of a paper published in the May number of the Monthly Notes of the Royal Astronomeal Society by Professor G. W. Hough, Director of the Dearborn Observatory of the Northwestern University, Evanston, Ill.

latitude is found a rotation period $9^h\ 50^m \pm$, and this shorter period may possibly extend to 20° of latitude.

8. The periods $9^h\ 55^m +$ and $9^h\ 50^m \pm$ are found in the same latitude, and probably at the same time.

9. It seems to me that the complicated motions observed on the surface of the planet are best explained by assuming the existence of a number of layers, or strata, at different depths below the surface, in which are located the objects under observation.

Monthly Notices, May, 1900.

Revised List of Stars with Annual Motion of 1″ and Over.

J. G. PORTER.

NAME OF STAR.	MAG.	R. A. 1900.			DECL. 1900.		MOTION
		h	m	s	°	′	″
Cordoba Z. 5^h, 243	8	5	7	42	− 45	2.7	8.71
Groombridge 1830	7	11	47	13	+ 38	26.2	7.03
Lacaille 9352	7.5	22	59	25	− 36	25.8	6.88
Argentine G. C. 32416	8.5	23	59	31	− 37	51.0	6.22
61 Cygni, pr	5.5	21	2	25	+ 38	15.4	5.23
61 Cygni, fol	6.5	21	2	26	+ 38	15.2	5.16
Lalande 21185	7.5	10	57	52	+ 36	38.4	4.73
ε Indi	4	21	55	43	− 57	11.8	4.68
Lalande 21258	8.5	11	0	31	+ 44	2.4	4.47
40 Eridani	5	4	10	40	− 7	48.5	4.07
μ Cassiopeiae	5.5	1	1	37	+ 54	25.8	3.77
Weiss' Argel. 11702	9	15	4	44	− 15	59.1	3.72
α Centauri, mean	1	14	32	48	− 60	25.4	3.68
Weiss' Argel. 11703	9	15	4	45	− 15	54.1	3.66
Lacaille 8760	7.5	21	11	24	− 39	15.3	3.44
Lacaille 1060	4	3	15	56	− 43	27.1	3.11
Oeltzen's Argel. 11677	9	11	14	50	+ 66	23.3	3.04
α Groombridge 34	8	0	12	40	+ 43	27.3	2.85
Piazzi 2^h, 123	6.5	2	30	36	+ 6	24.6	2.33
Lalande 25372	8.5	13	40	40	+ 15	26.0	2.30
Struve P. M. 2164	8	18	41	40	+ 59	28.7	2.29
Lacaille 661	6.5	2	6	24	− 51	18.8	2.27
α Bootis	1	14	11	6	+ 19	42.2	2.27
Weisse I 5^h, 592	8.5	5	26	23	− 3	41.7	2.21
Lalande 7443	8.5	3	56	32	+ 35	1.9	2.20
β Hydri	3	0	20	30	− 77	49.0	2.19
Bradley 3077	6	23	8	28	+ 56	37.0	2.09
Piazzi 14^h, 212	5	14	51	37	− 20	57.9	2.06
ζ Toucani	4	0	14	52	− 65	27.8	2.03
Weisse I 9^1, 954	9	9	46	10	− 11	49.3	1.97
Lalande 15290	8.5	7	47	10	+ 30	54.8	1.95
τ Ceti	3.5	1	39	25	− 16	27.9	1.94
Auwers' A. G. C. 4999	9	13	40	13	+ 18	20.3	1.91
σ Draconis	5.5	19	32	33	+ 69	29.5	1.83
Lacaille 2957	6	7	41	51	− 33	58.6	1.72
Fedorenko 1457-8, mean	7.5	9	7	35	+ 53	7.0	1.70
δ Pavonis	3.5	19	58	55	− 66	26.2	1.64
Lalande 30694	7.5	16	47	56	+ 0	10.9	1.63

REVISED LIST OF STARS WITH ANNUAL MOTION OF 1″ AND OVER.

NAME OF STAR.	MAG.	R. A. 1900.			DECL. 1900.		MOTION
		h	m	s	°	′	″
Lacaille 8362	6	20	4	38	− 36	21.2	1.61
Lacaille 4887	6	11	41	45	− 39	57.4	1.58
61 Virginis	5	13	13	10	− 17	45.3	1.51
Lalande 31055	7.5	16	59	51	− 4	53.8	1.49
ζ′ Reticuli	5.5	3	15	36	− 62	57.5	1.47
Groombridge 1618	6.5	10	5	15	+ 49	57.6	1.45
Lalande 30044-5	7.5	16	25	33	+ 4	26.1	1.45
ν Indi	6	22	16	2	− 72	44.5	1.45
ζ² Reticuli	5.5	3	16	2	− 62	53.3	1.43
Lalande 27744	7	15	8	50	− 0	57.8	1.39
Lalande 38383	7.5	19	59	41	+ 23	5.0	1.39
Lacaille 147	5.5	0	32	13	− 25	19.1	1.38
Becker A. G. C. 5072-3 m	9	14	21	7	+ 24	6.1	1.37
Lalande 6888-9	8	3	40	12	+ 41	9.0	1.36
Piazzi o^h, 189	6	0	43	8	+ 4	46.0	1.35
Fedorenko 1384	8.5	8	45	59	+ 71	10.9	1.35
Lacaille 3386	6.5	8	28	57	− 31	10.9	1.34
Weisse I 17^h, 322	7.5	17	20	47	+ 2	14.0	1.34
Lalande 46650	8.5	23	43	59	+ 1	52.3	1.34
α Canis maj	1	6	40	45	− 16	34.7	1.32
γ Serpentis	3.5	15	51	50	+ 15	59.3	1.31
Oeltzen's Argel. 17315-6	9	17	37	0	+ 68	25.8	1.30
Weisse I 23^h,175	8	23	11	55	− 14	21.9	1.30
Weisse I 16^h, 906	9	16	50	8	− 8	9 1	1.29
85 Pegasi	6	23	56	57	+ 26	33.2	1.29
Lacaille 4955	7	11	52	58	− 27	8.7	1.28
36 A Ophiuchi	5	17	9	12	− 26	27.4	1.28
Lacaille 8381	5.5	20	9	3	− 27	19.9	1.28
ι Persei	4	3	1	51	+ 49	13.9	1.25
Weisse 4^h, 1189	6.5	4	55	51	− 5	52.3	1.25
α Canis min	1	7	34	4	+ 5	28.9	1.25
Bradley 2179	6	17	10	4	− 26	24.1	1.25
Munich 18180	9	18	53	7	+ 5	48.5	1.23
η Cassiopeiae	4	0	43	3	+ 57	17.2	1.21
43 Comae	4	13	7	12	+ 28	23.1	1.20
Lalande 28607	7	15	37	42	− 10	30.4	1.20
Weiss' Argel. 16089	8.5	20	17	42	− 21	39.7	1.20
δ Trianguli	5.5	2	10	57	+ 33	46.0	1.17
Lalande 15565	7.5	7	54	21	+ 29	31.1	1.16
Lacaille 7215	7	17	12	9	− 34	52.7	1.15
Fedorenko 2544	7.5	14	52	21	+ 54	4.3	1.13
70 Ophiuchi	4.5	18	0	24	+ 2	31.4	1.12
Lacaille 8620	6	20	51	3	− 44	29.2	1.11
θ Ursae Maj	3	9	26	10	+ 52	8.0	1.10
Bradley 1584	6	11	29	38	− 32	18.1	1.09
π Mensae	5.5	5	45	8	− 80	32.7	1.08
72 Herculis	5.5	17	16	55	+ 32	35.8	1.04
Lacaille 8267	6	19	55	32	− 67	34.9	1.04
Lalande 16304	6.5	8	13	39	− 12	17.6	1.02
Lalande 27026-7	8	14	46	0	− 23	52.8	1.02
Weisse I 21^h, 502	9	21	24	30	− 12	56.4	1.02
Lalande 5490-6	7	2	55	58	+ 61	19.9	1.00
ε Eridani	3	3	28	13	− 9	47.8	1.00

OBITUARY NOTICE.

RALPH COPELAND.

Charles Piazzi Smyth was born at Naples on 3 January 1819. His father was the well-known Admiral W. H. Smyth, whose numerous works on astronomy, written in a genial and popular style, has done so much to spread the love of astronomy in the British Islands. Doubtless the father's great personal regard for the venerable Italian astronomer Piazzi, then at Naples, led to the choice of the christian name by which his son was eventually so well known in the astronomical world. Educated at Bedford Grammar School, Piazzi Smyth was appointed assistant at the Cape Observatory in 1835 under Maclear. He assisted Maclear in the observation of Halley's comet and more particularly in making the typical drawings published in vol. X of the R. A. S. Memoirs. Seven years later he observed the Great Comet of 1843, of which he made a fine series of observations extending from March 5 to April 19, despite the imperfect character of the available instruments, the best of which seems to have been a portable equatorial of 3½ inches aperture. The general appearance of this great comet he preserved in a striking oil-painting which often called forth the admiration of astronomical friends in after years. Besides taking part in the regular work of the observatory he shared in the verification and extension of Lacaille's arc of meridian. The triangulation, in particular, involved much exposure notably in the winter of 1845 when he occupied the station of Sneeuw Kop at an elevation of 5070 feet above the sea. This was the last of his South African work, as he left the Cape shortly afterwards on his appointment to succeed Henderson as Astronomer Royal for Scotland and Professor of Practical Astronomy in the University of Edinburgh. He carried with him the best wishes of Maclear, who speaks of him as "experienced in the details of meridian work, and unflinching in hardships" and adds that "he had a happy talent, with the assistance of his pencil, in conciliating the inhabitants, . . . and his robust constitution fitted him for taking an active share in the triangulation."

On arriving in Edinburgh Piazzi Smyth loyally determined to complete the reduction of the meridian observations made by Henderson. This work was carried out in conjunction with Mr. Alexander Wallace, who most efficiently filled the post of assistant from the time of Henderson's appointment in 1834 until the

end of 1880. In the course of his own work Piazzi Smyth greatly extended the investigations regarding the want of stability shown by the Transit Instrument, a defect which he eventually in great part remedied by discarding the movable Ys and their adjusting screws. This was done in 1848. The collected results of the Edinburgh meridional observations are published in vols. XIV and XV of the Edinb. Astr. Observations. In 1851 he went to Norway to observe the eclipse of the Sun in company with Dr. T. R. Robinson, the veteran Armagh astronomer. At their station on the Island of Bue near Bergen, the actual eclipse was obscured by clouds but the Professor, thanks to his skilful brush, brought home most successful sketches of the wonderful atmospheric coloring incidental to a solar eclipse. In 1856 he married Miss Jessie Duncan and in company with her sailed for Teneriffe in Mr. Robert Stephenson's yacht "Titania" on the expedition which gave so great an impetus to Mountain Astronomy. The scientific results of the mission are published in the Phil. Trans. for 1858, and more fully in Edinburgh Observations vol. XII, while their personal experiences in scaling the peak, and the circumstances of summer and autumn life at elevations of 9000 to 11000 feet above the sea are charmingly set forth in "Teneriffe, an Astronomer's Experiment", one of the few books illustrated with Photo-stereographs. Two further volumes entitled "Three Cities in Russia" are the outcome of another journey undertaken in 1859 to St. Petersburg, Moscow and Novgorod. The astronomical interest of this work centres in the account of Pulcova observatory and the circle of distinguished astronomers assembled there around the elder Struve.

In 1864 he published a volume entitled "Our inheritance in the Great Pyramid" in which he adopted and expanded certain eccentric ideas according to which this particular pyramid was the divinely revealed and universal standard of measure. The earlier part of the following year was spent in making an elaborate survey of the passages and chambers of the Great Pyramid together with determinations of their orientation. The details of this undertaking are given in Edinb. Observations vol. XII and also in the three volumes of "Life and Work at the Great Pyramid." Another volume, "On the Antiquity of Intellectual Man," Edinburgh, 1868, also bears on the hypotheses connected with the great pyramid. In recognition of the great pains and skill displayed in this work he was awarded the Keith Prize of the Royal Society of Edinburgh. The Professor's scientific friends would have been pleased had he contented himself with a strictly scien-

tific treatment of the orientation of the pyramid and its passages, but the mystical hypotheses which he associated with the Great Pyramid led to discussions and controversies that culminated in Piazzi Smyth's withdrawal from the Royal Society of London in 1874.

At this period Spectroscopy attracted his attention and with his usual energy he devoted himself to the study of the Solar spectrum, the Spectra of luminous gasses, of the Aurora and of the Zodiacal light. He was the first to thoroughly map the absorption lines due to atmospheric vapour, and to advocate their observation as a meteorological phenomenon. He did much to advance the "end-on method" in dealing with faintly luminous media, and laboratory spectroscopy in general owes much to his numerous papers on the subject, which were invariably written in the attractive style so peculiarly his own. Of special importance was the discovery of the rythmical relation between the chief lines of Carbonic Oxide gas, a discovery in which he was associated with Prof. Alexander Herschel. In furtherance of his spectroscopic studies he paid long visits to Winchester, to Portugal and to Madeira, accompanied, as in all his journeys, by Mrs. Smyth who most devotedly assisted him in all his researches. The chief results of these studies are contained in the following papers: "End-on illumination in private spectroscopy;" "The Solar spectrum in 1877–1878," for which he received the Makdougall-Brisbane prize of the Edinburgh Royal Society; "Carbon and Carbo Hydrogen, spectroscoped and spectrometed in 1879," all three published in 1879; "Madeira Spectroscopic," 1882; "The Visual (Grating and Glass Lens) Solar Spectrum in 1884," 1886; and "Micrometrical Measures of Gaseous Spectra under High Dispersions," 1886.

With a view to facilitating telescopic observations at sea Prof. Smyth devoted much time and expense to the construction of a "Free Revolver Stand" on the principle of the gyroscope. This contrivance was tried on the voyage to Teneriffe with a considerable measure of success, though the smallness of the yacht tested to the utmost the steadying power of the apparatus. Unfortunately an accident to the mechanism put a stop to this promising experiment, which seems never to have been repeated at sea. Another of his inventions was a Distance-measurer of which the particulars will be found in the account of his journey to Russia. In 1852 Piazzi Smyth organised a system of exact time-signalling by means of a time-ball, followed in 1861 by the

time-gun and sympathetic clocks in Edinburgh and afterwards in Dundee, which is still in operation. He gave much attention to the reduction of the temperatures shown by the deep-soil thermometers established on Calton Hill in 1837, and their comparison with the sunspot period and the mean temperature of Scotland. The results are depicted in the admirable graphic diagrams which form so conspicuous a feature of much of his work. Evidences of his artistic genius will be found in many of the vignettes on the title pages of the Edinb. Observations as well as in the illustrations of several of his popular books. He was also a skillful experimenter in all that concerned photographic methods from a relatively early date.

In 1888 he resigned the Directorship of the Observatory together with the Professorship in the University, which he had held for 43 years, and retired to Clova near Ripon in Yorkshire. With unflagging zeal he there continued his researches on the solar spectrum of which he made a large photographic chart with the aid of a Rowland grating. In 1895 he had the great misfortune to lose his wife, who for nearly forty years had been his faithful and untiring assistant in all his work. After Mrs. Smyth's death the Professor led even a more secluded life than before, though it is certain that he still busied himself with his favourite problems. He died on February 21, 1900 at Clova, where he as well as Mrs. Smyth are buried.

Though Piazzi Smyth is most widely known throughout the world by the mystical significance which he attributed to the Great Pyramid, his labours in sidereal astronomy, in mountain astronomy, in meteorology and especially in spectroscopy entitle him to a high place amongst the scientific worthies of the nineteenth century. To those who had the good fortune to know him personally he will ever be remembered as the most genial of hosts, ever ready to demonstrate the latest improvements of the always ingenious apparatus with which he chanced to be occupied at the time.

He was a corresponding member of the Academies of Munich and Palermo, and received the honorary degree of L L. D. from the University of Edinburgh. He was one of the oldest fellows of the Royal Astronomical Society having been elected as far back as 1846.

ASTRONOMISCHE NACHRICHTEN, Royal Observatory, Edinburgh, April, 1900.

SPECTROSCOPIC NOTES.

In the *Astrophysical Journal* for June Prof. Vogel describes the large spectrograph built for use with the new 33-inch photographic refractor of the Potsdam Observatory. The collimator objective has a focal length of 48 centimeters (19 inches) and an aperture of 3 cm. (1.2 in.). The camera objective has a focal length of 56 cm. (22 in.) and an aperture of 4 cm. (1.6 in.); this may however be replaced for certain purposes by a cemented triple objective with a focal length of 41 cm. (16 in.) and the same aperture. The three simple prisms by Steinheil are of Jena glass which has a refractive index of 1.67 for the *Hγ* line in the violet, and which is very white. The refracting angle of the prisms is 63.°5, their height 4.0 cm. (1.6 in.), and the lengths of their refracting faces respectively 6.0 cm. (2.4 in.), 6.5 cm., and 7.0 cm. The whole is specially designed to prevent flexure in the parts. On trial the instrument has given gratifying results.

Prof. Vogel also contributes to the same number a very readable summary of the progress made in the last decade in the determination of stellar motions in the line of sight; a branch of spectroscopic science to which the aforesaid instrument will doubtless soon be making notable contributions.

In his Report to the Board of Visitors to the Greenwich Observatory the Astronomer Royal states (*Observatory*, July) that the 28-inch telescope has been used to examine Capella in accordance with Mr. Newall's suggestion that this spectroscopic binary might possibly be seen visually as a double star. An elongation was detected by several observers, and the position angle of this elongation varied consistently with the period of 104 days of the revolution of the spectroscopic components. This, it will be noticed, is about one fortieth of the period of the most rapid known visual binary.

The will of Prof. Piazzi Smyth makes provision for the publication of his spectroscopic manuscripts, and also for the assistance or promotion every ten or twenty years of an exceptional expedition for the study of some particular branch of astronomical spectroscopy at mountain elevations of not less than 6,000 feet.

An extended description of Prof. Smyth's spectroscopic work is contributed to *Nature* of June 14 by Prof. A. S. Herschel.

Among this year's Birthday honors is the promotion to K. C. B. of Dr. Gill, under whose very energetic directorship of the Observatory of the Cape of Good Hope important spectroscopic researches have recently been added to the other work of the Observatory.

The detailed spectroscopic measures have appeared from which Herr Belopolsky has been able to decide in favor of the short period of the rotation of Venus, (*Astronomische Nachrichten*, No. 3641; *Nature*, June 14). The photographs of the spectrum cover a period of time from the end of March to the middle of May, during which the planet was near greatest eastern elongation. The values obtained vary from 0.7 to 0.3 kilometers per second corresponding to values of the rotation period of 16 to 37 hours. The observations, while failing on account of the smallness of the quantity measured to fix the period of rotation closely, seem conclusive in showing that the real period of rotation is of the order of 24 hours.

If the report in *Science* is complete it would seem that the vice-president of section A of the American Association for the Advancement of Science at the New York meeting in his address on the subject of the teaching of astronomy in the United States did not so much as allude to the opportunities, difficulties, and progress of the teaching of spectroscopic astronomy.

Sir Norman Lockyer's study of the spectrum of α Aquilae (*Proceedings of the Royal Society*, No. 427) leads him to adopt the suggestion, originally offered by Prof. Pickering and later accepted by Prof. Vogel, that the haziness of the lines of the spectrum is the result of the star's rapid rotation. Using Prof. Scheiner's device of comparing with the spectrum of the sun or another star out of focus he finds that the spectrum of α Aquilae is much more like that of β Arietis and the Sirian stars than like that of α Cygni, with which Prof. Vogel originally classified it. He finds also that instead of Prof. Vogel's 17 miles per second the width of the lines is such as to require a velocity of more than 40 miles per second of rotation.

The new star in Aquila recently discovered by Mrs. Fleming from an examination of the Harvard plates follows the example of previous new stars in giving after its decline from maximum the spectrum of a planetary nebula.

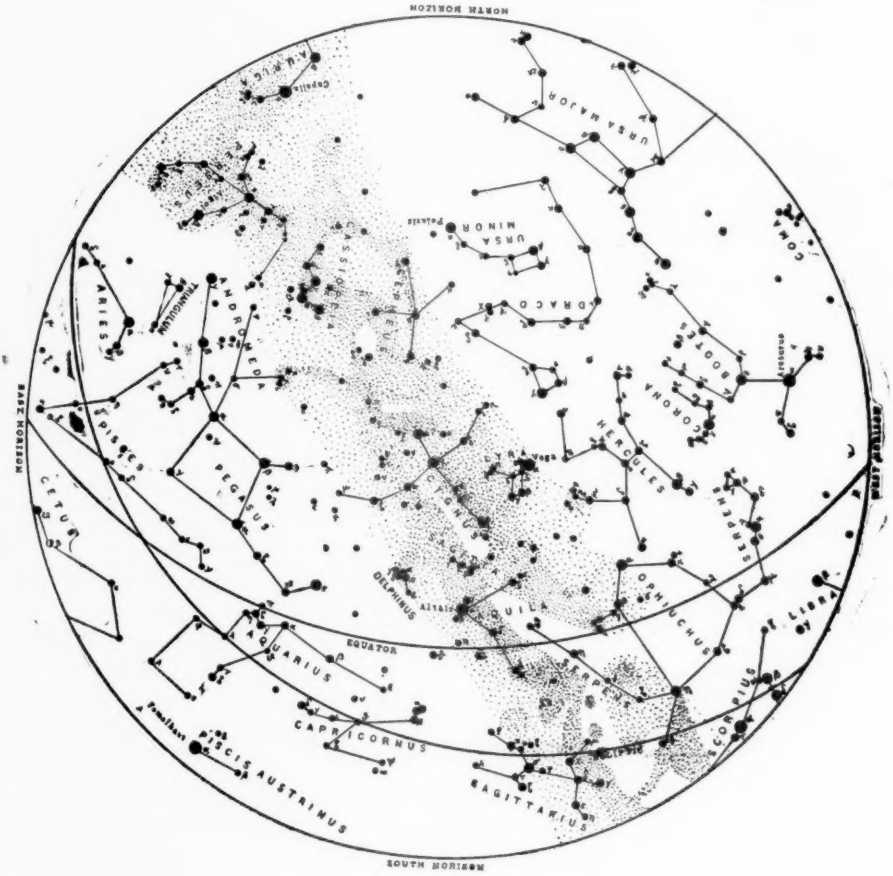
In the *Astrophysical Journal* for June Mr. Wright gives measures of photographs of the spectrum of ε Leonis taken with the Mills spectrograph of the Lick Observatory which do not confirm the variability of the velocity in the line of sight of that star announced by Mr. Adams from observations at the Yerkes Observatory.

The explanation of the continuous spectrum of the corona is the subject of an interesting communication of Prof. Scheiner to *Astronomische Nachrichten* No. 3647. In the continuous spectrum which the corona shows in addition to the bright line spectrum the dark lines are very weak. Consequently this part of the corona's light cannot be simply reflected sunlight, but must be largely light whose source is incandescent matter in the solid or liquid state. Such matter is found in the meteors which are undoubtedly present in great numbers near the sun's surface. If these, instead of simply reflecting the sun's light, are themselves the source of a luminous radiation which constitutes part of the light of the sun's corona, the necessary high temperature of the meteors must be explained. That the meteors are raised to a temperature of incandescence by friction in a rare medium, like the shooting stars of the earth's atmosphere, or by collisions, is improbable. Prof. Scheiner suggests, however, that direct radiation may be sufficient. The amount of heat received by a body so close to the sun would be very great; but on the contrary the radiation from a meteor, with no atmosphere to retain the heat, would be very free. Prof. Scheiner's conclusion is, from the rather meagre data available, that a meteor at a distance from the sun's surface equal to the sun's radius would reach a temperature of incandescence.

PLANET NOTES FOR AUGUST AND SEPTEMBER.

H. C. WILSON.

Mercury will be morning star during August, reaching greatest western elongation, 18° 32′ from the Sun, Aug. 19. The planet may then be seen a little north of east, about an hour before sunrise. On Sept. 13, Mercury will be at



THE CONSTELLATIONS AT 9 P. M., SEPTEMBER 1, 1900.

superior conjunction, so that during that month the planet will be invisible to the eye.

Venus is the splendid morning star which one sees now, a little north of east, about three o'clock. She attains her greatest brilliancy on the morning of Aug. 14, and will continue to be the brightest "star in the east" for months to come. Venus and the Moon will be in conjunction on the mornings of Aug. 21 and Sept. 19. On Sept. 17 she reaches greatest elongation west from the Sun, 46° 3′.

Mars is now between the horns of Taurus and will move eastward through Gemini into Cancer during these two months. This planet can be observed only in the morning hours. Mars and the Moon will be in conjunction Aug. 20 and Sept. 18.

Jupiter is evening star, seen toward the southwest in Scorpio. In September Jupiter will be too far west for observation except in the early twilight. Jupiter and the Moon will be in conjunction Sept. 1 and 29. The planet will be at quadrature Aug. 25.

Saturn crosses the meridian now at about 9 o'clock and toward the end of September at a little after 5 o'clock P. M. It is the bright golden-colored star which you see in the Milky Way toward the south in the evening. Saturn will be at quadrature Sept. 21 and in conjunction with the Moon Sept. 3 and 30.

Uranus will be at quadrature Sept. 1, and in conjunction with the Moon Sept. 2 and 29. This planet, just below the limit of vision with the unaided eye in brightness, is among the stars in Scorpio southeast from Jupiter, and may be recognized when found by its dull greenish disc.

Neptune may be found in the morning, between 3° and 4° west from the star η Geminorum. It is not in convenient position for observation.

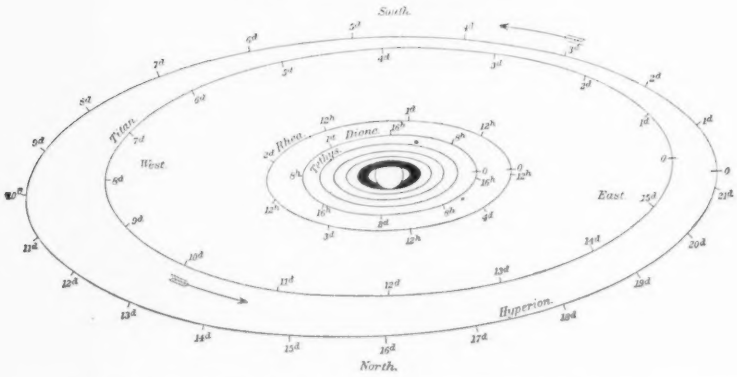
The Moon.

		Phases.	Rises. (Central Standard Time at Northfield; Local Time 13m less.) h	m	Sets. h	m
Aug.	24	New Moon	5	01 A. M.	6	29 P. M.
Sept.	2	First Quarter	2	00 P. M.	11	09 "
	8	Full Moon	6	01 "	6	20 A. M.
	15	Last Quarter	10	48 "	2	23 P. M.
	23	New Moon	5	56 A. M.	5	44 "

Occultations Visible at Washington.

Date. 1900.		Star's Name.	Magnitude.	IMMERSION. Washington M. T. h	m	Angle f'm N pt. °	EMERSION. Washington M. T. h	m	Angle f'm N pt. °	Duration. h	m
Aug.	26	*e* Leonis	5.3	6	18	142	7	11	262	0	53
Sept.	12	η Arietis	5.7	7	10	43	7	49	286	0	39
	12	ρ^1 Arietis	7.0	9	08	64	10	01	260	0	53
	12	ρ^3 Arietis	6.0	9	57	26	10	37	296	0	40
	12	50 Arietis	6.8	12	13	132	12	44	186	0	31
	12	54 Arietis	6.3	16	00	75	17	21	256	1	21
	13	B.A.C. 1242	6.3	12	16	153	12	29	176	0	13
	14	*i* Tauri	5.0	13	28	55	14	32	288	1	04
	27	*i* ^{1}Librae	5.0	6	54	69	7	56	300	1	02

The Satellites of Saturn.



APPARENT ORBITS OF THE SEVEN INNER SATELLITES OF SATURN, AT OPPOSITION IN 1900, AS SEEN IN AN INVERTING TELESCOPE.

I. MIMAS.

Period $0^d\ 22.6^h$

	h		
Aug. 21	10.5	P. M.	E
22	9.1	"	E
23	7.7	"	E
24	6.3	"	E
29	10.7	"	W
30	9.3	"	W
31	8.0	"	W
Sept. 1	6.6	"	W
7	9.6	"	E
8	8.2	"	E
9	6.9	"	E
16	8.5	"	W
17	7.1	"	W
18	5.8	"	W
24	8.8	"	E
25	7.5	"	E
26	6.1	"	E

II. ENCELADUS.

Period $1^d\ 08.9^h$

	h		
Aug. 21	9.4	P. M.	E
23	6 3	A. M.	E
24	3.2	P. M.	E
26	12 1	A. M.	E
27	9.0	"	E
28	5.9	P. M.	E
30	2.7	A. M.	E
31	11.6	"	E
Sept. 1	8 5	P. M.	E
3	5.4	A. M.	E
4	2.3	P. M.	E
5	11.2	"	E
7	8.1	A. M.	E
8	5 0	P. M.	E
10	1.9	A. M.	E
11	10.7	"	E
12	7.6	P. M.	E
14	4.5	A. M.	E
14	1.4	P. M.	E
15	10.3	"	E
18	7.2	A. M.	E
19	4.1	P. M.	E
21	1 0	A. M.	E
22	9 9	"	E
23	6.8	P. M.	E
24	3.7	A. M.	E
26	12.6	P. M.	E
27	9.5	"	E
29	6.4	A. M.	E
30	3.3	P. M.	E

III. TETHYS.

Period $1^d\ 21.3^h$

	h		
Aug. 22	9.2	A. M.	E
24	6.5	"	E
26	3.8	"	E
28	1.1	"	E
29	10.4	P. M.	E
31	7.7	"	E
Sept. 2	5.0	"	E
4	2 3	"	E
6	11.6	A. M.	E
8	8 9	"	E
10	6 3	"	E
12	3.6	"	E
14	12.9	"	E
15	10.2	P. M.	E
17	7 5	"	E
19	4 9	"	E
21	2.2	"	E
23	11 5	A. M.	E
25	8.8	"	E
27	6.1	"	E
29	3.5	"	E

IV. DIONE.

Period 2^d 17.7^h

	h		
Aug. 22	5.1	A. M.	E
24	10.8	P. M.	E
27	4.5	"	E
30	10.2	A. M.	E
Sept. 2	3.9	"	E
4	9.6	P. M.	E
7	3.3	"	E
10	9.0	A. M.	E
13	2.7	A. M.	E
15	8.4	P. M.	E
18	2.1	"	E
21	7.8	A. M.	E
24	1.5	"	E
26	7.2	P. M.	E
29	1.0	"	E

V. RHEA.

Period 4^d 12.5^h

	h		
Aug. 21	10.4	P. M.	E
26	10.8	A. M.	E
30	11.2	P. M.	E
Sept. 4	11.6	A. M.	E
9	12.1	"	E
13	12.5	P. M.	E
18	1.0	A. M.	E
22	1.5	P. M.	E
27	2.0	A. M.	E

VI. TITAN.

Period 15^d 23.3^h

	h		
Aug. 23	11.7	A. M.	W
27	9.7	"	S
31	7.6	"	E
Sept. 4	8.8	"	I
8	10.6	"	W
12	8.7	"	S
16	6.6	"	E
20	7.9	"	I
24	9.7	"	W
28	8.0	"	S

VII. HYPERION

Period 21^d 7.6^h

	d	
Aug.	22.2	W
	28.2	S
Sept.	2 4	E
	7.1	I
	12.6	W
	18.5	S
	23 7	E
	28.5	I

VIII. JAPETUS.

Period 79^d 22.1^h

	d	
Aug.	10.9	E
	30.1	I
Sept.	19.7	W
Oct.	10.4	S

Phenomena of Jupiter's Satellites.

Central Standard Time.

	h	m				h	m			
Aug. 25	6	46	P. M.	II	Tr. In.	10	6	55	P. M.	II	Oc. Dis.
	6	53	"	I	Oc. Dis.	12	6	24	"	II	Sh. Eg.
	7	29	"	III	Oc. Dis.		7	49	"	III	Tr. Eg.
26	6	23	"	I	Tr. Eg.	17	7	11	"	I	Oc. Dis.
	7	41	"	I	Sh. Eg.	18	6	44	"	I	Tr. Eg.
27	6	43	"	II	Ec. Re.		7	56	"	I	Sh. Eg.
Sept. 1	8	49	"	I	Oc. Dis.	19	6	26	"	II	Sh. In.
2	6	05	"	I	Tr. In.		6	33	"	II	Tr. Eg.
	7	22	"	I	Sh. In.	23	6	50	"	III	Ec. Re.
	8	19	"	I	Tr. Eg.	25	6	28	"	I	Tr. In.
3	6	45	"	I	Ec. Re.		7	37	"	I	Sh. In.
	6	46	"	II	Oc. Re.	26	6	43	"	II	Tr. In.
	6	52	"	II	Ec. Dis.		6	59	"	I	Ec. Re.
5	6	34	"	III	Sh. Eg.	28	6	34	"	II	Ec. Re.
9	8	02	"	I	Tr. In.	30	6	29	"	III	Oc. Re.

NOTE.—In. denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., Eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

VARIABLE STARS.

J. A. PARKHURST.

Maxima and Minima of Long Period Variables.

1900 October and November.

MAXIMA.	Oct.
ST Cygni	1
WR Hydrae	1
RR Virginis	2
S Librae	4
SS Cygni	5?
U Andromedae	6
T Capricorni	6
RT Cygni	6
V Capricorni	8
T Sagittarii	11
RR Aquilae	12
R Piscium	12
R Piscis Aust.	13
R Sculptoris	13
V Bootis	14
V Coronae	15
T Ophiuchi	15
S Scorpii	17
R Persei	18
R Draconis	19
R Microscopii	21
V Cassiopeae	22
U Librae	23
W Aquarii	24
— Aquarii	26
R Camelopardalis	26
X Scorpii	26
U Piscium	29
S Sagittarii	29
R Delphini	30
— Pegasi	30
RV Sagittarii	30

MAXIMA, Con't.	Nov.
S Pyxidis	2
Z Aquilae	3
S Cygni	3
R Andromedae	5
RS Herculis	8
T Aquarii	10
S Columbae	10
T Hydrae	10
V Lvrae	15
R Pegasi	15
W Monocerotis	19
S Sculptoris	19
R Arietis	20
W Aquilae	22
U Cancri	23
T Ursae Maj.	24
W Ceti	26
V Cygni	26
V Ophiuchi	26
Y Capricorni	28
T Sagittae	28
U Capricorni	30

MINIMA.	Oct.
U Ceti	2
T Sagittae	9
R Virginis	9
RR Cygni	11
R Sagittarii	12
R Leonis	21
R Ceti	23
U Virginis	24
T Canum Ven.	27
R Vulpeculae	29
S Coronae	31
	Nov.
T Librae	6
S Canis min.	16
V Cancri	18
S Piscium	19
V Aurigae	20
V Tauri	20
V Geminorum	26
S Geminorum	29
T Herculis	29
S Cassiopeae	30

NOTES TO THE EPHEMERIS.

LONG PERIODS.

ST CYGNI—The maximum calculated for Oct. 1, needs considerable correcrection. The star was fading towards minimum the latter part of July, and will pass the minimum probably in November. The discrepancy seems to have arisen from the assumption of 4 instead of 5 periods as having elapsed between the maxima of 1893 and 1898.

—*AQUARII*—Maximum. Oct. 26. The place of this star for 1885 is, R. A. $21^h\ 7^m\ 28^s$, Dec. 3° 29.′6, according to Dr. Hartwig.

—*PEGASI*—Maximum Oct. 30. The place of this star for 1855 is R. A. $21^h\ 14^m\ 8^s$, Dec. + 13° 50′.3.

FAINT MINIMA—Three of the stars in the above list have been found very faint at minima. T Librae was <16th magnitude in April, V Lyrae <15th magnitude in May, and S Cygni <16th magnitude in July.

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time.)

1900.

U CEPHEI.

	d	h
Sept.	3	16
	8	16
	13	16
	18	15
	23	15
	28	14
Oct.	3	14
	8	14
	13	13
	18	13
	23	13
	28	12

ALGOL.

	d	h
Sept.	7	22
	10	19
	13	15
	16	12
	19	9
	30	20
Oct.	6	14
	9	11
	12	7
	23	19
	26	16
	29	12

λ TAURI.

	d	h
Sept.	9	24
	13	23
	17	21
	21	20
	25	19
	29	18
Oct.	3	17
	7	16
	11	15
	15	14
	19	12
	23	11
	27	10
	31	9

U OPHIUCHI.

$P = 0^d\ 20.1^h$.

Sept.	0	8
	30	13
Oct.	31	13

R CANIS MAJ.

$P = 1^d\ 3.3^h$.

	d	h
Sept.	0	19
	30	8
Oct.	31	0

S CANCRI.

	d	h
Sept.	2	11
	11	22
	21	10
	30	22
Oct.	10	9
	19	21
	29	9

U CORONAE.

	d	h
Sept.	7	7
	17	16
Oct.	4	22
	8	9
	15	7
	18	17

Y CYGNI.

$2P = 2^d\ 23.9^h$.

Odd min.

Aug.	29	17
Sept.	28	16
Oct.	28	15

W. DELPHINI.

	d	h
Sept.	7	20
	12	16
	17	11
Oct.	6	16
	11	12
	16	7
	30	17

DM + 45°3062.

	d	h
Sept.	4	5
	8	18
	13	8
	17	22
	22	12
	27	1
Oct.	1	15
	6	5
	10	19
	15	8
	19	22
	24	12
	29	2

ALGOL-TYPE STARS.

The ephemeris for Y Cygni is taken from Dunér's latest elements in No. 3633 of the *Nachrichten*. The rest of the ephemeris, both for long-periods and Algol stars, is taken from Dr. Hartwig's paper in the *Vierteljahrsschrift*, Vol. 34, part 4.

NEW VARIABLE OF THE SS CYGNI TYPE.—Dr. Hartwig has a note in No. 3652 of the *Nachrichten* stating that Stanley Williams' new variable in Cygnus, BD. + 46° 2966, resembles U Geminorum and SS Cygni in the rapidity of its rise to maximum. The position is

R. A.	20^h	28^m	9.7^s	Dec. + 43°	6.′1, (1855)
		29	38.0		15. 2, (1900)

The range of variation is stated by Dr. Hartwig to one and one-quarter magnitudes, but it was estimated as 7.0 magnitude by Prof. Krueger 1857 June 19, and has lately been seen not much, if any, brighter than the 10th magnitude. Its period is stated as 15.2 days, and it passed a maximum about 1900 July 1. It is so near α Cygni that it can be easily located without circles. See also Nos. 3629, 3632 and 3637, of the *Nachrichten*.

COMET NOTES.

New Comet Borrelly-Brooks, 1900 b (July 23)—A new comet was discovered by Prof. W. R. Brooks of Rochester, N. Y., an hour after midnight July 23 in R. A. $2^h\ 43^m\ 40^s$ and Dec. $+\ 12°\ 30'$. It has been moving quite rapidly northward and on Aug. 3 was in the constellation Perseus in R. A. $2^h\ 58^m$ and Dec. $+\ 45°\ 30'$. The comet is quite bright but not visible to the naked eye. It has a stellar nucleus of about the 10th magnitude and a tail about 1° in length.

A telegram received Aug. 10 gives the following provisional elements and ephemeris computed by C. D. Perrine of the Lick Observatory from observations on July 25, July 30, and Aug. 4.

Elements by Perrine.

$T =$	Aug. 3.21	
$\omega =$	12°	27′
$\upsilon =$	328	0
$i =$	62	3
$q =$	1.0148	

Ephemeris for Greenwich Midnight.

	R. A.			Dec.		Light.
	h	m	s	°	′	
Aug. 10	3	15	16	+ 63	41	0.83
14	3	34	44	+ 72	17	
18	4	12	28	+ 79	11	
22	5	46	24	+ 84	11	0 43

From *Astronomische Nachrichten* No. 3653 we learn that the comet was discovered by Borrelly at Marseilles, at $12^h\ 50^m$ Marseilles time, July 23, so that Borrelly precedes Brooks by about 5½ hours in the discovery of the comet.

Finding Ephemeris for Comet 1894 IV. (E. Swift)—In a supplement to *Astr. Nach.* No. 3653 is given a short finding ephemeris for the faint periodic comet discovered by Edward Swift in 1894 and which is probably identical with the lost comet of De Vico, 1844 I. The ephemeris was computed by Mr. Frederick H. Seares, now in Berlin. The calculated light of the comet renders the search for it this year almost hopeless, since it was seen with the greatest difficulty in 1894 and the computed light this year is only one ninth as great as then.

Ephemeris for Berlin Midnight.

1900	R. A.			Dec.		log. Δ	Aberration.	
	h	m	s	°	′		m	s
July 23	15	53	28	−24	32 8	0.2496	14	46
27		53	42	24	30.7	.2552	14	58
31		54	26	24	30.2	.2608	15	10
Aug. 4		55	39	24	30.8	.2666	15	22
8		57	20	24	32.8	.2724	15	34
12	15	59	31	24	36.0	.2784	15	47
16	16	02	10	24	40.2	.2845	16	00
20		05	17	24	45.4	.2906	16	13
24		08	50	24	51.4	.2967	16	27
28	16	12	50	−24	58.1	0.3026	16	40

The light ratios compared with the light at the time of discovery in 1894 are

1900	$1:r^2\Delta^2$	$1:r^2$
July 23	0.12	0.35
Aug. 28	0.11	0.42

GENERAL NOTES.

We have held this number back several days longer than previously announced, in order to get the latest plans and instructions for observations of the planet Eros, to determine its parallax. Work has already begun, and this opposition of Eros offers a favorable opportunity for the observations desired.

The Late James E. Keeler.—The news of the death of Professor James E. Keeler, Director of the Lick Observatory, Mt. Hamilton, California, will be sad news to scientific circles the world over. It occurred Sunday, Aug. 19, in San Francisco, after a brief illness, the particulars of which have not come to hand. A full account of the life work of Mr. Keeler will be given in our next, by persons well qualified to speak of it.

A Few Astronomical Instruments is the title of a fine quarto volume in board and cloth covers giving excellent, full-page plate illustrations of some of the astronomical instruments made by the well-known firm of Warner & Swasey, Cleveland, Ohio. It is only a few years since this firm began work on astronomical instruments. We well remember with what hesitation and self distrust the first steps in this new line of telescope-making for them was undertaken. It is now very remarkable that in so few years it should be possible for any instrument makers to have achieved such a reputation, for high grade work, on the largest scale, as that enjoyed today by Messrs. Warner and Swasey. One has only to open this neat, new book to find illustrations of telescopes having object glasses varying from 6 to 40 inches in diameter, bearing the impress of their handy and skillful work, in mounting or other contrivance to put the working astronomer at his nightly task with ease and comfort hitherto unknown. In this new volume we not only find refracting telescopes of various sizes of the most modern and approved pattern, but also meridian circles and photograhic instruments with all the appliances which the ingenuity of the electrical and mechanical engineer can devise to transform the drudgery of the taxing routine work of the observer into the delight and exhiliration of pure observational research. Of late we have wondered what Herschel would do and say if he were privileged now to use one of America's great refracting telescopes. If his enthusiasm was kindled inordinately with the help of such telescopes as he could make for the study of the heavens, his wonderful genius aided by the celestial views of the modern telescope would have given him insight and an impression of mind that would have filled his longing and devout soul, not with fancy and theory, however probable, but with fact and sublime reality which he so loved and bravely sought with all his great mental power.

The reason for the rapid growth of the reputation of the firm of Warner & Swasey in the new line of telescope making is not hard to understand. They went at it deliberately. They had the means and the ability to experiment exhaustively on new and difficult methods of mounting telescopes. They had skill enough to make a dome for an observatory that has proved to be a perfect success. We have used two of their steel domes, large and small, for fifteen years, and we now say we could reasonably ask for nothing better. They have made position micrometers that work very well and keep a good record for steadiness in time under certain astronomical tests. They do well and faithfully many other kinds of work in scientific lines that we have not the space now to

speak of. But the one very difficult piece of machinery, which has occupied the attention of these makers for some time, is the structure of a dividing engine for ruling the fine measuring circles which are a necessity to all instruments of precision. To make such an engine, whose errors of division are less than values easily seen by good visual apparatus, is a problem that has baffled the ingenuity and the skill of the best mechanical engineers down to the present time. We notice a cut of a dividing machine in this book, and we have heard something of the fine work that can be done by it. We sincerely hope that the problem of producing highly accurate dividing apparatus has been solved by Warner & Swasey for it will certainly mean much for Warner & Swasey and for science generally. Later we hope to print a cut and an explanation of this new ruling engine.

Military Rank of Professors of Mathematics in the United States Navy.—The Navy Register for 1900 gives the *real*, not *relative* or *assimilated*, rank of all Professors of Mathematics in the Navy up to January 1, 1900. On the active list we find: "With rank of Captain:" Profs. Hendrickson, Todd and Oliver. "With rank of Commander:" Profs. Brown, Rawson, Alger and Dodge. "With rank of Lieutenant:" Profs. Paul, Skinner, See and Updegraff.

On the retired list we find: "Rank of Rear Admiral:" William Harkness. "Rank of Captain:" Profs. Newcomb, Hall and Eastman. "Rank of Commandder:" Profs. Frisby, Prudhomme and Rice.

The equivalent ranks in the army are as follows:

Rear Admiral	with	Maj. General.
Captain	"	Colonel.
Commander	"	Lt. Colonel.
Lt.Commander	"	Major.
Lieutenant	"	Captain.

Total Solar Eclipse May 28, 1900. Observed by Party from Leander McCormick Observatory.—The party from the Leander McCormick Observatory of the University of Virginia was stationed at Winnsboro, S. C. The day of the eclipse was beautifully clear and the programme was carried out successfully.

The equipment included a camera having a lens of five inches aperture and 39 ft. focal length. Seed's triple-coated plates having 27x as the upper emulsion were employed. Ten plates were secured during totality. The exposures were made by Mr. J. W. Mayo of the Engineering Department of the University of Virginia, assisted by Mr. J. W. Hanehon of Winnsboro. Several smaller cameras were also mounted on a polar axis, the plates being exposed by Messrs. J. A. Lyon and E. O. Eastwood of the Observatory. One of these cameras having a focal length of four feet was provided with a color screen. The negative obtained shows no detail owing to failure of the clepsydra to work properly, but the intensity of the coronal image is such as to indicate that good results might easily be obtained with a long focus camera. Visual observations were made by Mr. H. R. Morgan of the Observatory and Prof. H. L. Smith of Davidson College with four inch refractors and myself with a six inch refractor. Preceding the eclipse, observations were made for the determination of latitude and longitude.

The polar coronal filaments greatly resembled those of the eclipse of 1878, but seemed at the time longer than those seen at Denver. On the other hand the equatorial filaments were not so well defined nor did they interlace to the same

extent as in 1878, being more nearly radial and consequently not intersecting except at some distance from the sun's limb. Vastly more of detail was seen in the telescopes than is shown on the negatives. No relation was noticed in the former between the filaments and the protuberances, although carefully looked for. Such relation is however apparent on the negatives, at least in the case of one of the principal prominences seen. On the negatives made also, the forms of some of the filaments were interesting. In the region between the two principal prominences, for instance, there are filaments which near their base are directed away from the sun's equator, while at a distance higher above the sun's limb they curve back again toward the equator. In this case, at least, the filaments do not form elliptic curves having their foci at the centre of the sun.

To the United States Naval Observatory and to Mr. Geo. N. Saegmuller the expedition was indebted for the use of instruments, to Prof. W. W. Campbell for valuable advice and for developing the plates obtained with the forty foot camera, to the Southern Railway and the Western Union Telegraph Company for railway and telegraphic facilities, and to the authorities and people of Winnsboro for their untiring and helpful courtesies.

Occultation of Saturn.—The following observations of the occultation of Saturn on July 10, 1900, were made at the Chamberlin Observatory, University Park, Col. The twenty inch refractor was equipped with a power of 200. The six inch refractor was used by Prof. Chas. J. Ling, and the five inch by Julian O. Howe. The atmospheric conditions were unfavorable. Local mean times are given; the position of the observatory is given in the American Ephemeris under the title "Denver."

Immersion.

	20-inch.			6-inch.			5-inch.		
	h	m	s	h	m	s	h	m	s
Outer edge of ring				7	59	3.6			
Encke's division	7	59	5.5						
Inner edge of ring			14.6			14.6			
First edge of ball			23.2			24.7			
Center of ball			43.6						
Second edge of ball	8	0	5.2	8	0	3.8			
Inner edge of ring			16.7			13.4			
Outer edge of ring			34.5			30.5	8	0	32.0

Emersion.

	h	m	s	h	m	s	h	m	s
Inner edge of ring	9	16	4.5						
1st contact with ball			20.2						
Center of ball			38.0						
2d contact with ball			58.2	9	17	1.0	9	17	1.0
Inner edge of ring		17	13.5			15.9			
Outer edge of ring			25.4			27.5			

HERBERT A. HOWE.

University Park, Colo., August 1900.

On July 21st *o Ceti* was observed and seemed equal to *Gamma Ceti* of third magnatude. On July 27th it seemed slightly less bright than that star, but was brighter than *Delta Ceti*.

The nights were clear and moonless. The maximum was predicted for July 31st. R. O. H.

San Francisco, August 10th.

Death of David Flanery.—Mr. David Flanery, well known to all readers of Popular Astronomy, died at his home in Memphis, Tenn., on August 6. Mr. Flanery was much interested in the variable stars, and has for many years been an observer of them. During the last six years he has followed up, among other stars, Mira Ceti and R Leonis with great persistency, and has furnished a number af maxima of these stars which are of considerable value. He has also kept watch of SS Cygni, and the new short-period star, SV Cygni, furnishing observations of them which the writer has been glad to use to supplement the gaps in his own.

Though knowing him only by letter, I have found him a genial and faithful correspondent, and an honest, open-minded and careful observer, always making the most and the best of such material and information as was accessible to him. He was very modest as to the value of his own astronomical work, and deserved to be more generally and favorably known to the regular astronomers than has been the case.

P. S. YENDELL.

Dorchester, Aug. 10, 1900.

Discovery of Comet Brooks.—It was my pleasure on the early morning of July 23 to discover a new bright comet in the eastern heavens; right ascension $2^h\ 43^m\ 40^s$; declination north 12° 30′. The motion of the comet was rapid, about three degrees daily, and in a northerly direction. The comet has a bright stellar nucleus, large coma and rather broad tail. In the 10¼ equatorial of this observatory, it is a very beautiful telescopic object, resembling a great naked eye comet in miniature. Discovered in the southern part of Aries it is at this writing in the head of Medusa and yesterday morning, was in the same low power field with Algol.

The approximate position of the comet this morning was as follows: Aug. 2nd $14^h\ 19^m$ E. ST. T. R. A. $2^h\ 55^m\ 35^s$; + 42° 34′. This position compared with the observation of yesterday morning, shows a daily motion of $1^m\ 25^s$ east, and 3° 3′ north. The nucleus has always appeared considerably elongated, until this morning it was nearly round.

WILLIAM R. BROOKS,

LINETTE OBSERVATORY, Geneva, N. Y.
August 3rd, 1900.

The Total Eclipse at Barnesville and Griffin, Ga.—Mr. Geo. A. Hill sends the following notes correcting and supplementing the very brief mention of the work at these stations in our paper in the last number of Popular Astronomy:

"The latitude and longitude of the station at Griffin, Ga., was determined by myself assisted by Mr. Littell. The site was selected, piers built, dark room constructed under my personal direction and in my judgment it was one of the finest that could have been found.

At Barnesville I made an accurate determination of the latitude and longitude, exchanging longitude signals with the Observatory here in Washington.

In addition we had with us Professor Lord, of the Ohio State University, equipped with his fine spectroscopic outfit. On the day of the eclipse Mr. Littell and I observed the first contact, each using one of the five inch equatorials. At the time of totality I had charge of the guiding telescope mounted on the polar axis, which held five cameras. Mr. Littell gave the proper time of exposure on each set. We secured four sets or twenty in all for the polar axis.

Mr. Peters, the photographer of the Observatory had immediate charge of the

40 foot lens. His devotion to his duty should not go unmentioned, for the end of the long focus lens was in a dark room, and he did not see the totality at all. Mr. Peters secured four plates with that lens. He was in charge of placing all the lenses in focus and his plates when published will indicate how well he did his work.

The two inner contacts were observed by Professors Eastman and Updegraff. Dr. See did not arrive at the station until two days before the eclipse and had nothing to do with preparing for the affair.

Professor Brown was in general charge of the station up to the day of the eclipse, but he observed from Griffin."

Occultation of Saturn by the Moon June 13, 1900.—This occultation was seen in a perfectly clear sky and good images. The instrument was a 4¼ inch refractor with a magnifying power of 160.

Ingress.—The planet was very pale, much less bright than the lunar disk and even the floor of Grinaldi or Plato. I saw no abnormal appearance on the rings or on the ball of Saturn. No dark band on the lunar limb.

Egress.—Same appearance. The egress was regular. Saturn always very little bright, but no trace of a lunar atmosphere. After 10 or 12 minutes the planet was seen to the naked eye. M. MOYE.

MONTPELLIER, (FRANCE)
June 12, 1900.

Corona Seen After Totality.—As the visibility of the corona after totality appears to have been a peculiar feature of the recent eclipse, the following notes may be of interest to readers of POPULAR ASTRONOMY.

The eclipse of May 28 was witnessed by the writer in Norfolk, Va., from a hotel roof secured for our party by the Hartford Scientific Association, and commanding a fine view of the surrounding country. Totality was due at about seven minutes before nine A. M. At 8:45 the Moon was far advanced upon the Sun, the daylight was distinctly dimmed and the air had grown cold. (The fall of temperature during the eclipse was found by one of the party to be more than fifteen degrees.*) At about eight minutes before nine totality was immanent, the crowd on the house-top was silent and minds were tense with expectation. I glanced at the Sun. The dwindling cresent formed now no more than a slight border upon the central zone of the Moon. Turning quickly toward the southwest where a moment ago the sky had been clear, or but slightly smoky along, the horizon, I saw, as it were, a black thunder cloud beyond the harbor and islands. I was unable to see the outline of the shadow advancing through the air, though to some of the party it was indistinctly visible. Indefinite darkness filled in two or three seconds the whole southwest sky. Meanwhile the shadow fell upon us in sudden successive waves. The daylight was, as it were, snatched away, and in a second or two again snatched away. I noticed at least three times this weird sinking of the daylight. Every beholder felt himself alone and overawed as the shadow fell. We were now enveloped in an unearthly twilight. When it was evident that the shadow was fully upon us, I turned to the east to look at the Sun. It hung black as ink in the sky with the corona springing from its equatorial zone in two wings or shafts of light like auroral streamers, seen beautifully aslant the sky. The western wing which was the longer could be

*This amount is so large there may be some mistake about it.—Ed.

traced nearly two solar diameters. Both wings were irregular at the boundary, and one, the eastern(?) flared more than the other, appearing in fanlike form. There were evidently structures just eluding vision (of the naked eye), but in the northern angle of the eastern wing my attention was fixed by a ray which curved back strongly from the polar regions, leaving almost a black shadow between itself and the bright polar filaments. From drawings made by members of the party I judge this may have formed the edge of a cone superposed upon the equatorial fan. The polar rays were beautiful silvery filaments springing singly from the sun's black poles. They were widely separated and quite long, the one in the northwestern angle, next the equatorial shaft seemed nearly equal to the Sun's diameter. All curved beautifully away from the poles, suggesting the lines of force about a disk magnet. I saw several bright dots on the Sun's edge which must have been prominences, but did not catch the delicate pink color of these and the rosy border on a portion of the Sun's edge seen by others of the party. Near by to the northwest of the Sun, Mercury shone out in fine flame color. The inky black globe of the Moon, the silvery wings of coronal light and the planet burning like a live coal through the sky formed a spectacle of weird beauty never to be forgotten. Barely had we looked at it however when a beaded mass of light broke out upon the western border of the Moon and unwelcome daylight dispelled the wondrous apparition. As partial compensation in this unhappy moment came an interesting and most unexpected phenomenon. At the instant of reappearance of the crescent, the equatorial wings of the corona vanished. But in their stead was seen a silver ring around the Sun, fringed with a flame pattern not previously visible. It called at once to mind a drawing of the inner corona in Young's Astronomy. For perhaps a second it was very bright, then I was aware of the return of daylight (which seemed to come perceptibly later than the reappearance of sunlight on the Moon's limb). To my still greater surprise the fringed ring did not vanish, but remained visibl: for what seemed a long time. This may have been ten seconds or so but I didn't count. One seemed to see this corona through a veil of glare like, for example, the beams from a search light in dusty air. At last it faded from sight and the eclipse was to all intents and purposes over. The inner corona has been reported as telescopically visible after totality at stations farther south. A possible connection is suggested between the prolonged display of the corona and the gradual falling of the shadow in this eclipse. Or the corona may have been unusually brilliant and so have outshone the returning daylight.

ANTONIA C. DE P. P. MAURY.

The Theory and Practice of Interpolation.—We have been much interested in a book recently published on The Theory and Practice of Interpolation by Herbert L. Rice, assistant in the office of the American Ephemeris, and Professor of Astronomy in the Corcoran Scientific School, Washington, D. C. It is in quarto form, consists of 234 pages, and is neatly printed by the Nichols Press of Lynn, Mass. In his office work the author has "felt the need of a book that would give, exclusive of other matter, a simple, practical and yet comprehensive discussion of all that is useful concerning *differences, interpolation, tabular differentiation and mechanical quadrature*," and, that should also include all tables auxiliary to the text needed by the practical computer.

In a brief review of this book, it seems to us that the author has carried out well, his design of bringing together these kindred themes and of treating them

in very plain and practical way. The first chapter which treats of differences speaks of the nature of a function in mathematical sense, then illustrates the notation of differences in tabular form, and immediately calls attention to a method of checking work for numerical accuracy. The theoretical part is stated in the form of theorems to be proved which, as far as we have noticed, are done in clear, concise and accurate way. The numerical examples which illustrate every important step in the development are an admirable feature which will at once attract the attention of the mathematical student.

This book contains, in our judgment, the clearest, fullest and best presentation of these topics that we know of either for study or for practical use in the hands of the computer. We think enough of it to adopt it in the post graduate course of study in Mathematics and Astronomy at Carleton College. It will be used at Goodsell Observatory as as reference book in respect to the themes of which it treats so fully and well.

Elements and Ephemeris of Comet *b* 1900 (Borrelly-Brooks.)—From Mr. Crawford's observation made on July 25th and my own of July 30th and August 4th, I find the following parabolic elements:

$$\begin{aligned} T &= 1900 \text{ August } 3\text{d}, 20726 \text{ Gr. M. T.} \\ \omega &= 12^\circ\ 26'\ 13.2'' \\ \Omega &= 328\ \ 0\ \ 30.1 \quad 1900.0 \\ i &= 62\ \ 30\ \ 46.3 \\ \log q &= 0.006390 \end{aligned}$$

Residuals (O − C): $\Delta\gamma' \cos\beta' + 4.4''$; $\Delta\beta' - 0.9$.

CONSTANTS FOR THE EQUATOR OF 1900.0

$$\begin{aligned} x &= r\,[9.945799] \sin(\ 86^\circ\ 21'\ 14.2'' + v) \\ y &= r\,[9.686698] \sin(283\ \ 9\ \ 4.5 + v) \\ z &= r\,[9.996636] \sin(\ 0\ \ 10\ \ 7.0 + v) \end{aligned}$$

EPHEMERIS FOR GREENWICH MEAN MIDNIGHT.

1900.		Time α h m s	Time δ ° ′	Log Δ	Br.
Aug.	10.5	3 15 15	+63 41.0	9.699	0.83
	14.5	3 34 46	72 17.2	9.746	0.65
	18.5	4 12 27	79 10.8	9.781	0.54
	22.5	5 46 25	84 11.3	9.823	0.43
	26.5	9 29 40	85 46.3	9.864	0.34
	30.5	12 5 24	83 37.7	9.902	0.27
Sept.	3.5	13 3 6	80 49.1	9.936	0.22
	7.5	13 30 37	78 13.1	9.968	0.18
	11.5	13 47 22	75 57.6	9.998	0.15
	15.5	13 59 9	74 0.1	0.025	0.12
	19.5	14 8 25	72 19.1	0.049	0.10
	23.5	14 16 17	70 52.6	0.072	0.09
	27.5	14 23 17	69 39.2	0.092	0.08
Oct.	1.5	14 29 46	68 37.4	0.111	0.07
	5.5	14 35 54	67 46.0	0.128	0.06
	9.5	14 41 53	67 4.4	0.144	0.05
	13.5	14 47 44	66 31.6	0.158	0.04
	17.5	14 53 33	66 7.2	0.171	0.04
	21.5	14 59 21	65 50.6	0.183	0.03
	25.5	15 5 12	+65 41.9	0.195	0.03

This comet seems to have been quite bright when discovered but to have faded rapidly since. On August 4th it was just visible to the naked eye, with a nucleus estimated at 10th magnitude. On July 28 the nucleus was elongated as seen with the 36-inch refractor. C. D PERRINE.

Mount Hamilton, California, Aug. 14, 1900.

Occultation of Saturn at St. Paul, Minn., July 10, 1900.—Mr. S. J. Corrigan of our city sent me some computations for the occultation of the planet Saturn, which took place Tuesday evening, July 10. I observed the times of immersion of both the ring and ball of the planet and sent my results to him. He advised sending them to POPULAR ASTRONOMY for publication.

Mr. Corrigan's computations for the times of all the phases for ball and ring were as follows:

IMMERSION (CENTRAL TIME).

	h	m	s
First contact with ring	9	24	47.2
" " " ball	9	25	11.6
Center of ball	9	25	28.8
Last contact with ball	9	25	46.0
" " " ring	9	26	10.4

Latitude + 44° 53′
Longitude 93° 05′ W. of Greenwich.

TIMES OF OBSERVATIONS were:

	h	m	s	DIFFERENCE. s
First contact with ring	9	24	45.0	+ 2.2
Center of Saturn	9	25	26.	+ 2 8
Last contact with ring	9	26	07.	+ 3.4

"The observed times are thus about three seconds earlier than the computed, which may be due to errors in the tabular places of the Moon and of Saturn. Washington observations of the late eclipse of the Sun indicate that the Moon was several seconds ahead of the computed time, and my observations would indicate that it was three seconds ahead in the times of this occultation."

I secured the time from Goodsell Observatory of Carleton College, at 6 o'clock P. M. I used a good watch for time-piece, and made these observations three-fourths of a mile northwest of the city hall of St. Paul. The occultation of the ring from first to last required just one minute and twenty-two seconds, and it was a beautiful sight. The last contact with the ring, I think, was observed to the fraction of a second, it was so distinctly seen.

T. D. SIMONTON.

We take the privilege of copying some of the private letter accompanying the above useful observations made by Dr. Simonton, to show amateurs what good work may be done sometimes with very simple means. ED.]

Professor H. T. Todd, Director of Nautical Almanac, Retired.—Professor H. T. Todd, Director of the Nautical Almanac, Washington, D. C., retired from office, Aug. 25, having reached the age limit for this branch of the Government service. The directorship of the Nautical Almanac will be assumed by Professor S. J. Brown, Astronomical Director of the Naval Observatory.

We learn from the *Washington Star* (Aug. 25) facts of unusual interest in the service of Professor Todd. He was graduated from the Naval Academy in 1857, was two years under Capt. Dupont, in Chinese waters, was present at the attack on the Taku forts in 1858 and at Tien Tsin when the treaty was signed. He was next on duty on the coast of Africa and took part in capturing the slaver, Erie, with 897 slaves on board. He was one of the officers of the prize crew ordered to take the slaves to Monrovia, and to bring the ship, her captain and mates into a United States port. This capture was an important one, as the

ship was condemned, and the captain of the Erie was hanged, being the only officer of a slaver ever executed for participation in the slave trade.

Professor Todd was appointed Professor of Mathematics in the Navy in 1877, and served eight years as head of the department of Physics and Chemistry at the Naval Academy. In 1886 he was placed on duty in the Nautical Almanac office, and continued there until he became Director, which position he held at the time of his retirement.

A New Star in Aquila.—From an examination of the Draper Memorial photographs, Mrs. Fleming has discovered a new star in the constellation Aquila. Its position for 1900 is R. A. $= 19^h\ 15^m\ 16^s$, Decl. $= -0°\ 19'.2$. It was too faint to be photographed on 96 plates taken between August 21, 1886, and November 1, 1898, although stars as faint as the thirteenth magnitude are visible on some of them. It appears on 18 photographs taken between April 21, 1899, and October 27, 1899. On April 21 it was of the seventh magnitude, and on October 27, 1899, of the tenth magnitude. Two photographs taken on July 7, and July 9, 1900, show that the star is still visible, and that its photographic magnitude is about 11.5. A photograph taken on July 3, 1899, shows that its spectrum resembled those of other new stars, while a photograph taken on October 27, 1899, shows that the spectrum resembled those of gaseous nebulæ.

On July 9, 1900, the object was discovered with the 15-inch Equatorial by Professor Wendell, who estimated its magnitude as 11.5 to 12.0, and confirmed the mono-chromatic character of its spectrum. E. C. PICKERING.

HARVARD COLLEGE OBSERVATORY,
Cambridge, Mass., July 11, 1900.

POSITIONS OF EROS (433) IN 1893, 1894 AND 1896.

Approximate positions of Eros (433) during the oppositions of 1894 and 1896 will be found in Circulars No. 36 and 37. Since then, the photographs from which these positions were derived have been measured by the method described in the Harvard Annals, Vol. XXVI, p. 237, and reduced by the method of Turner. The measurements have been made by Miss E. F. Leland, and the reductions by Miss A. Winlock aided by Miss I. E. Woods. These photographs were taken with the Bruce, Bache and Draper photographic doublets, whose apertures are 60, 20 and 20 cm., and the focal lengths such that 1 mm equals 60″, 179″, and 163″, respectively. Photographs taken with these instruments are designated by the letters A, B, and I, respectively. The smaller instruments photograph a field 10° square, and as some of the images fall near the corners of the plates it was not supposed that positions could be determined from them with a high degree of accuracy. In some cases, the images are more than 5° from center of plates and are consequently much distorted, the greatest diameter exceeding a minute of arc; yet, as will be seen below, the accuracy of the places does not greatly differ from that ordinarily obtained with the meridian circles. The most remarkable conclusion to be derived from these observations is that if, in the future, any other object like Eros should be discovered, we have at this Observatory the means of tracing its path since 1890, during the time in which it was moderately bright, with nearly as great accuracy as if a series of observations had been taken of it with a meridian circle.

In the following table the designation of the original negative is given in the

first column. The date, the Greenwich Mean Time of the middle of the exposure, and the duration of the exposure, are given in the next three columns. Two enlargements, on a scale of 0.1 cm. = 10″, were made from each of these negatives, and their designations are given in the fifth column. The number of catalogue stars on these enlargements used to determine the constants of the plates, such as errors of scale, orientation, etc., is given in the sixth column. The standard coördinates of Erosare given in the seventh and eighth columns, and the resulting right ascension and declination for 1875, in the ninth and tenth columns. The two measures of each plate are

POSITIONS OF EROS.

Plate.	Date.			G. M. T.		Exp.	Enl.	St	X	Y	R. A. 1875.			Dec. 1875.			ΔR. A	ΔD.
	y	*m*	*d*	*h*	*m*	*m*			″	″	*h*	*m*	*s*	°	′	″	*s*	″
I 9801	1893	10	28	21	55	14	6441	9	— 9627.2	—15941 0	5	58	48.11	+53	39	46 8	+0.03	—0.1
							6442	9	— 9626.9	—15941.2	5	58	48.14	+53	39	46.7		
I 9832	1893	10	30	20	18	10	6377	9	+ 9760 3	—14440.0	6	4	33.13	+54	6	25 8	+0.03	—1.3
							6378	9	+ 9760 7	—14441.3	6	4	33.16	+54	6	24.5		
I 9862	1893	10	31	21	21	15	6391	7	—10903.8	+ 3653.4	6	7	37 42	+54	20	11 2	+0.40	+2.2
							6392	7	—10900 1	+ 3655.3	6	7	37 82	+54	20	13 4		
I 10095	1893	11	26	20	26	17	6390	7	—15368.2	+ 4066.2	7	17	31.35	+57	49	34.0	—0.29	—1.0
							6389	7	—15370.6	+ 4065.5	7	17	31 06	+57	49	33.0		
I 10215	1893	12	19	18	21	14	6375	4	+10544.4	+ 5340.3	7	45	56.41	+54	38	39 2	+0.28	+0.1
							6376	4	+10546 8	+ 5340 5	7	45	56.69	+54	38	39.3		
I 10280	1893	12	23	19	49	13	6416	4	—10591.8	— 642.9	7	45	57.59	+52	58	10.4	—0.19	—1.7
							6417	4	—10593 7	— 644.5	7	45	57.40	+52	58	14.7		
I 10321	1893	12	27	17	32	10	6383	7	+10580 3	+10362.3	7	44	43.17	+50	55	0 2	+0 03	—0.6
							6382	7	+10580 7	+10361.7	7	44	43.20	+50	54	59.6		
I 10469	1894	1	19	16	57	10	6408	7	— 654 1	—15761.6	7	26	28.40	+28	45	48.4	—0.20	+0.9
							6409	7	— 656.7	—15760 7	7	26	28.20	+28	45	49.3		
I 10559	1894	1	25	16	16	13	6393	9	— 3564 4	+11541.9	7	23	33.46	+21	14	58.0	—0 01	—1.0
							6394	9	— 3564.6	+11541.0	7	23	33.45	+21	14	57.0		
A 222	1894	2	5	15	26	60	6410	7	— 4630 1	+ 5011.8	7	23	17.83	+ 8	45	22 8	—0.05	+1.9
							6411	7	— 4630.8	+ 5013.7	7	23	17.78	+ 8	45	24 7		
A 246	1894	2	16	14	49	12	6414	8	+ 1059 4	— 9589 6	7	29	55 55	— 0	21	42.7	—0 08	+0.6
							6415	8	+ 1058.2	— 9589 0	7	29	58 47	— 0	21	42.1		
I 10685	1894	2	16	14	59	13	6436	11	+10997.4	—13093.8	7	29	59.01	— 0	21	54.4	—0.32	—3.6
							6437	11	+10992 6	—13097.4	7	29	58 09	— 0	21	58.0		
B 10909	1894	4	16	14	13	10	6371	7	+ 2201 3	+13823.8	9	17	0.62	—13	33	54.0	—0 03	+1.8
							6374	7	+ 2200.9	+13825.6	9	17	0.59	—13	33	52.2		
B 10951	1894	4	18	14	29	10	6365	9	+ 8489 9	+12761.3	9	21	47 01	—13	38	52.7	—0.10	+1.3
							6370	9	+ 8488 5	+12762 6	9	21	46 91	—13	38	51.4		
B 11174	1894	5	19	14	16	10	6344	7	+ 7170.1	—10985.5	10	38	1.88	—14	57	21 9	+0 10	+3.6
							6346	7	+ 7171.6	—10981 9	10	38	1.98	—14	57	18 3		
B 15531	1896	4	6	20	52	60	6360	7	— 7958.9	— 3771.5	18	36	59.92	—38	32	48 8	+0 03	+1.0
							6361	7	— 7958.6	— 3770.5	18	36	59.95	—38	32	47.8		
B 16108	1896	6	4	16	40	70	6350	5	—10686.4	— 9103.3	18	30	6.81	—40	2	45.2	+0.75	+0 2
							6351	5	—10677 8	— 9102.7	18	30	7 56	—40	2	45.0		
B 16157	1896	6	5	19	54	10	6355	5	+15242.6	+ 8861.3	18	27	51.27	—39	58	33 0	+0.24	+0.7
							6357	5	+15245 4	+ 8861 9	18	27	51.51	—39	58	32.3		
B 16165	1896	6	5	22	4	11	6353	4	+ 1306 6	— 8891.1	18	27	39 55	—39	58	2 1	+0.07	+3.4
							6354	4	+ 1307.4	— 8887.7	18	27	39 62	—39	57	58 7		
B 16518	1896	6	29	19	17	15	6348	9	— 9732 7	+ 4124.9	17	37	43 91	—36	21	26 7	—0.09	+1.4
							6349	9	— 9733.9	+ 4126.3	17	37	43.82	—36	21	25.3		
A 1876	1896	6	30	13	46	60	6413	6	— 5804 8	+ 4719.0	17	36	22.23	—36	11	20.9	0.00	+0.5
							6412	6	— 5804.8	+ 4719 4	17	36	22 23	—36	11	20.4		

independent, except for errors in the original negatives and in the method of reduction. The differences in the two results for the right ascension, and for the declination, are given in the last two columns.

On I 9832, the image is irregular. The position of the brightest part is given. The center precedes it 0ˢ.66, and is 8″.6 south. On A 222 and A 1876, the images are much elongated, owing to the motion of Eros. The means of the measures of the ends are given. The discordance in the positions derived from I 10685 and B 16108 is probably due to the poor quality of the images.

A complete discussion of these measures, including the original settings and the results for each comparison star, is in course of preparation for the Annals.

The positions of the stars have been taken from the Catalogues of the Astronomisches Gesellschaft, except in the case of the plates taken in 1896 for which the Cordoba Catalogues have been used. The average value of the 296 residuals for the catalogue stars is, for x, $\pm$ 1″.03, for y, $\pm$ 1″.06. The average difference of the standard coördinates of the two positions of Eros is, for x, $\pm$ 1″.8, for y, $\pm$ 1″.4. For the three Bruce plates these values become $\pm$ 0″.6, and $\pm$ 1″.0, respectively.

EDWARD C. PICKERING.

HARVARD COLLEGE OBSERVATORY, Circular No. 51,
June 7, 1900.

Occultation of Saturn at Providence, R. I., July 10, 1900.—The occultation of Saturn by the Moon, July 10, was observed at Seagrave Observatory, this place, with the following results:

		h	m	s
Immersion.	First contact	11	17	8
	Second contact	11	17	24
Emersion.	Third contact	12	35	59
	Fourth contact	12	36	17

These results are given in Providence local mean time.

Our party was located at Southern Pines, North Carolina, for observations of the total solar eclipse of May 28. Our position was longitude + 79° 20′ and latitude + 35° 15′. We secured six good photographs during totality which lasted just 96 seconds. The photographs were taken with a Clark 4-inch objective, five feet focal length. The plates have been examined very carefully, but no trace of Intra-Mercurial planet is found. The Corona was seen by the writer with a three-inch telescope two minutes before and after totality.

F. E. SEAGRAVE.

PROVIDENCE, R. I., July 13, 1900.

The Eclipse of Last May.—Professor Charles A. Young, of Princeton, gives, in the *Independent* of Aug. 30, some results of the observations of the total solar eclipse of May 28, 1900. In that article he says "no really brilliant discovery was made, since anything of that sort would have been announced; nor can it be expected that any very remarkable extension of our knowledge will prove to have been gained, because in every respect except the weather, the circumstances of the eclipse were rather unfavorable." The unfavorable conditions referred to were the short time of totality (less than 100 seconds), and the fact that the sunspot period was near the time of its minimum. The short period of totality was unfavorable for visual or photographic purposes and the time of minimum of the spot period is unfavorable because of the quiescent state of the solar surface. The time of contacts at stations where latitude and longitude were accurately known agree in showing that the eclipse was four or five seconds ahead of time, and some of the observers were of the opinion that the length of totality was notably shorter than the computed time. This last statement is a surprise to us, and we wonder what the real cause of such an opinion is. We can guess two things that might contribute somewhat to such a result: one is the fact that some observers were at fault in beginning their observations; another may be that some stations were not as near the center line of totality as was supposed when they were chosen. If the error of position in this regard was small the difference in time of the length of totality would not be noticeable; but if it was considerable it would shorten the obseuration somewhat.

Professor Young says that the Princeton party at Wadesboro photographed the last contact with an exposure of about one-half second, purposely instead of making it instantaneously. The result was to get *positives* of the Sun's disk instead of *negatives*, but they were as sharp as the negatives of the first contact.

The conclusion of the article gives some results that are best expressed in Professor Young's own words, as follows:—

"My own special observational objective, for instance, was to determine by accurate measurement the true position of the bright green line in the spectrum of the corona, which line I had identified in 1869 (probably erroneously, as now appears) with the so-called "1474" line of the chromosphere spectrum. In 1869, 1870 and 1878 I had not the least difficulty in seeing it all through the eclipse, and did not dream of any embarrassment on that score at this time. But in my instrument, an "integrating spectroscope" which showed clearly the dark 1474 line in the spectrum of a cloudy sky, I failed to see the corona line at all; and my assistant, with essentially the same instrument that I used in 1878, caught only a glimpse of it, too faint and momentary to permit any measurement. The failure to photograph it was less surprising, as the available time of exposure was very short.

"The flash-spectrum observations and photographs were also many of them failures, but there were some successes, and when we get the full reports of the Johns Hopkins photographs, and of those obtained with Sir Norman Lockyer's twenty-foot prismatic camera, and of several other parties on both sides of the Atlantic, we may find that considerable advance has been made in our knowledge of the constitution and characteristics of this most interesting and significant spectrum, especially as to its ultra-violet regions. For these reports we shall, however, have to wait till November at least, and perhaps much longer. The study and measurement under the microscope of such complicated photographs is a time-consuming process.

"There can be no doubt that the experience gained on this occasion will be of the greatest value to the fortunate observers of the eclipse of next May, when the totality will last more than six minutes, and when it is expected that the solar energies will have begun to resume their usual activity.

"The "intra-Mercurial planet" photographic campaign, instituted by Professor W. H. Pickering, seems to have been a failure. The shortness of totality was such as to make success more than doubtful from the outset on account of necessary limitation of exposure, and the brightness of the sky. Next year these difficulties will vanish.

"Professor Turner, of Oxford, was quite successful in his photograhic study of the polarization of the light of the corona. He pursued a method substantially like that used by Professor Wright in 1878, but with improvements. The amount of reflected light in the corona is shown to be very considerable; in fact, it seems likely that on this occasion the principal portion of the light was of this character, the gaseous true radiation (which produces the bright lines in the corona-spectrum) having been relatively very feeble.

"The "shadow-bands," which appear for about a minute and a half just before and after totality, were well observed at several stations. It seems to be conclusively shown that they are of atmospheric origin—a phenomenon closely analgous in cause and nature to the twinkling of the stars, and due to the passage of the light through moving masses of air of unequal density. For their formation it is necessary that the light should come from a line of star-like points, such as the narrow crescent of the Sun when almots covered by the Moon."